# MILL CREEK PASSAGE
# GOSE STREET CONCEPTUAL DESIGN

## PROJECT # 21-1010

### DRAFT - BASIS OF DESIGN REPORT

**Prepared for**

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**June 2023**

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# 1 INTRODUCTION

The Tri-State Steelheaders are sponsoring the development of conceptual designs for Mill Creek fish passage improvements at the Gose Street bridge crossing just outside the City of Walla Walla (Figure 1). The fish passage barrier is located at the transition between an engineered flood control channel lined with riprap and concrete and a more natural stream setting with the bed and banks composed of cobble and gravel. The flood control infrastructure on Mill Creek reduces peak flows and captures sediment upstream of the Gose Street project reach. The Walla Walla County Conservation District constructed two concrete fishways and two concrete channel-spanning weirs in 2008 to help improve fish passage at the transition between the two channel types. A large flood in February 2020, however, caused about 4 to 5 feet of channel incision below the lower fishway and created a passage barrier due to the drop. The February 2020 flood is considered the flood of record and at its peak, about 4,700 cfs of water flowed through the Mill Creek channel (U.S. Army Corps of Engineers 2021). An emergency repair was constructed in the transition area by the Washington Department of Fish and Wildlife during October 2020. The emergency repair included the construction of two weirs from ecology blocks to break the 5-foot jump into two smaller jumps, but this short-term fix is not designed to withstand typical flood flows in Mill Creek and does not meet the drop criteria for fish passage. The purpose of the conceptual designs is to develop potential alternatives that will address fish passage issues over the long term, while protecting existing infrastructure and not increasing flood risks for local landowners.

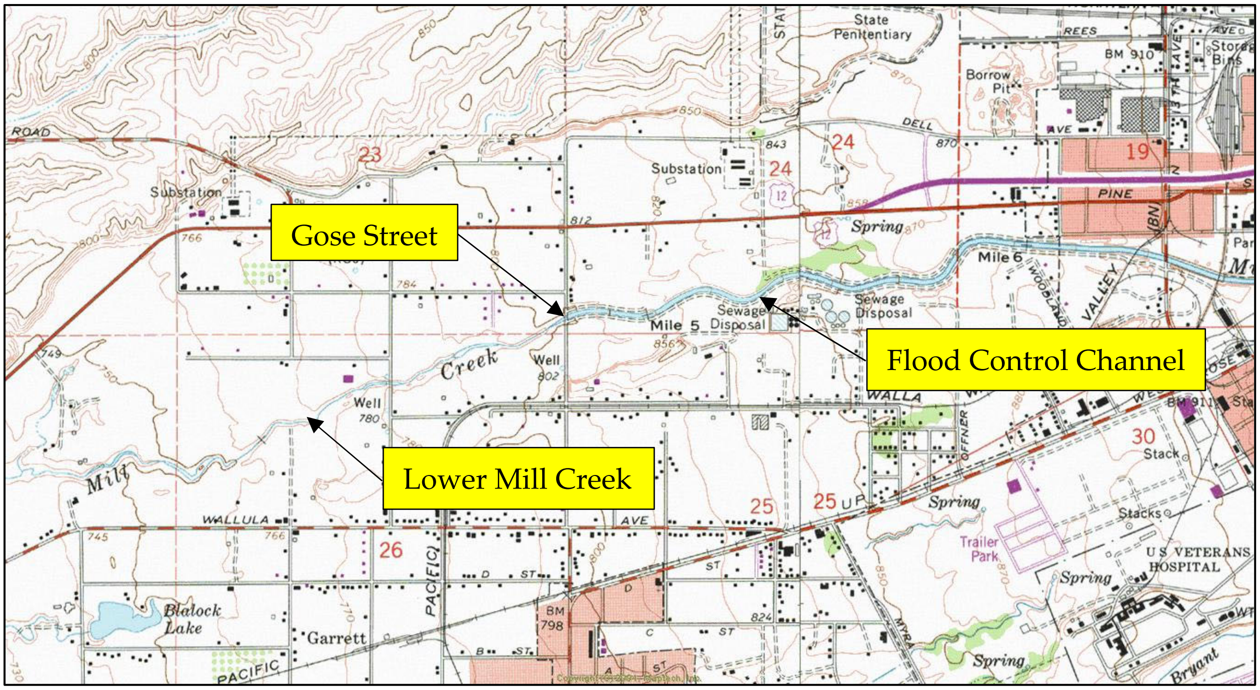


**Figure 1 – Mill Creek project area. The Gose Street bridge is located at RM 4.8 on Mill Creek.**

# 2 MILL CREEK GEOMORPHIC ASSESSMENT – GOSE STREET REACH

**DRAFT**

# Geomorphic Assessment of the Gose Street Reach of Mill Creek near Walla Walla, Washington

**Report to Tri-State Steelheaders Salmon Enhancement Group**

**Mill Creek Passage Design – Gose Street Conceptual Design**

**January 18, 2023**

# Geomorphic Assessment of the Gose Street Reach of Mill Creek near Walla Walla, Washington

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Cover Photo: *Downstream view of Mill Creek at about Station 19+00, which is 1,900 feet upstream from the Hussey Road crossing and about 700 feet below the Gose Street crossing.*

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# 1.0 Introduction

Tri-State Steelheaders is sponsoring the development of conceptual designs for Mill Creek fish passage improvements at the Gose Street bridge crossing just outside the City of Walla Walla (Figure 1). The fish passage barrier is located at the transition between an engineered flood control channel lined with rip-rap and concrete and a more natural stream setting with the bed and banks composed of cobble and gravel. The flood control infrastructure on Mill Creek reduces peak flows and captures sediment upstream of the Gose Street project reach. The Walla Walla County Conservation District constructed two pool-and-chute fishways and concrete channel-spanning weirs in 2008 to help improve fish passage at the transition between the two channel types. A large flood in February 2020, however, caused about 4 to 5 feet of channel incision and created a passage barrier at the fishway. The February 2020 flood is considered the flood of record and at its peak, about 4,100 cfs of water flowed through the Mill Creek channel (U.S. Army Corps of Engineers 2021). An emergency repair was constructed in the transition area by the Washington Department of Fish and Wildlife during October 2020. The emergency repair included the construction of two weirs from ecology blocks to break the 5-foot jump into two smaller jumps, but this short-term fix is not designed to withstand typical flood flows in Mill Creek. The purpose of the conceptual designs is to develop potential alternatives that will address fish passage issues over the long term, while protecting existing infrastructure and not increasing flood risks for local landowners.

This geomorphic assessment of lower Mill Creek has been undertaken to better understand the cause of the incision in the channel below the fishway and to evaluate changes in channel conditions that could influence the design of fish passage improvements. The project reach is about 2,600 feet in length and runs between the Gose and Hussey Street crossings of Mill Creek from approximately river mile (RM) 4.4 to RM 4.8. Project stationing referenced in the report begins at the Hussey Street crossing (Station 0+00) and proceeds upstream to the Gose Street crossing at Station 26+00. The pool-and-chute fishway is at Station 25+00.

# 2.0 Mill Creek Basin Geology

The Mill Creek basin is located in the Blue Mountains region of southeastern Washington and is part of the larger Walla Walla River basin that feeds into the Columbia River near Wallula Gap. Most of the Blue Mountains are underlain by Columbia River Basalt (CRB) lava flows. The lava flows, including Grande Ronde, Wanapum, and Saddle Mountains basalt, occurred about 12 to 16 million years ago. Uplift of the Blue Mountains is attributed to isostatic rebound of the crust from the added weight of the basalt flows and north-south horizontal tectonic stresses. The rapid uplift caused many of the rivers in the area, such as the Grande Ronde, Tucannon, John Day, and Walla Walla rivers, to carve deep canyons through the basalt.

Cooling during the Pleistocene (2 million to 10,000 years ago) led to the advance of large continental ice sheets into the northern half of Washington state. Repeated glacial advances and retreats occurred during this time. Massive glacial lakes that were dammed by the ice sheet


*2021 USDA NAIP orthophotograph; Gose and Hussey Street crossings of Mill Creek are highlighted with yellow dots.*

**Figure 1.** Current conditions in the Gose Street reach of Mill Creek.

periodically breached and caused enormous floods across the landscape. The Missoula floods scoured much of the terrain in southeastern Washington down to bedrock and left flood deposits throughout the region.

The lower Mill Creek basin is underlain by the Frenchman Springs Member of the Wanapum basalt flows (MVwfs) deposited about 15 million years ago (Figure 2; Derkey et al. 2006). The basalt is overlain by two sets of Miocene-Pliocene clastic sediments. The lower unit consists predominantly of fine-grained sediment (MRf), while the upper unit consists largely of coarser clasts that have formed a cemented conglomerate (MRcg) (Figure 3). The fine-grained sediment unit is known only from well logs and consists of silt, sandy silt, sandy mud, and blue, green, and yellow clay. The lower unit varies in thickness over short distances, which may be due to faulting or rapid changes in depositional environments as debris was shed from the Blue Mountains. The coarse-grained conglomerate in the upper unit consists of a sequence of variably cemented sandy gravel with a muddy to sandy, silicic to calcic matrix that underlies much of the Walla Walla River basin. The rounded clasts are predominantly basaltic in composition. The conglomerate is distinguished from younger alluvium by the presence of weathered basalt clasts, clay matrix, and cementation that is absent from the younger deposits.

Most of the exposed sediments in the lower Mill Creek basin consist of relatively recent deposits of loess, glacial Lake Missoula slack-water flood deposits, and alluvium (Figure 3). The glacial slack-water deposits are known as Touchet beds (Qfst2) and were formed by ponding of floodwaters behind Wallula Gap during Lake Missoula floods. The Touchet beds consist of well-stratified rhythmic beds, normally graded, fine- to medium-grained felsic to basaltic sand at the base, grading upward to felsic silt (Derkey et al. 2006). Individual beds range from a few inches to about 3 feet thick. The remnant buttes within the lower Mill Creek valley are Touchet beds that have been dissected and eroded on all sides by streamflow over thousands of years. The well-bedded deposits are often mantled by up to 6 feet of fine-grained loess, but the loess may be a thin layer and is not distributed evenly. The youngest deposits in the basin consist of Holocene alluvium adjacent to stream channels and floodplains. The alluvium may include discontinuous, unconsolidated deposits of clay, silt, fine sand, and gravel.

# 3.0 Lower Mill Creek Geomorphology and Historical Conditions

Mill Creek flows westward from the Blue Mountains and flows across a broad alluvial fan as it enters the Walla Walla River valley. Mill Creek is largely confined by steep basalt valley walls for about 17 miles before reaching the alluvial fan in the Walla Walla River valley. Multiple distributary channels were historically present on the broad area covered by the fan. Distributary channels form on lower gradient alluvial fan surfaces where sediment deposition exceeds the sediment transport capacity of the stream. The high sediment load can lead to regular channel avulsions during floods. The primary distributary channels include Garrison Creek, Yellowhawk Creek, and Stone Creek. The distributary channels routed water and sediment across much of the fan during floods. The stream was likely well connected to its adjacent floodplain due to the high sediment load. Numerous springs were also present in the western half of the fan as groundwater daylighted to the ground surface along the edge of the fan.

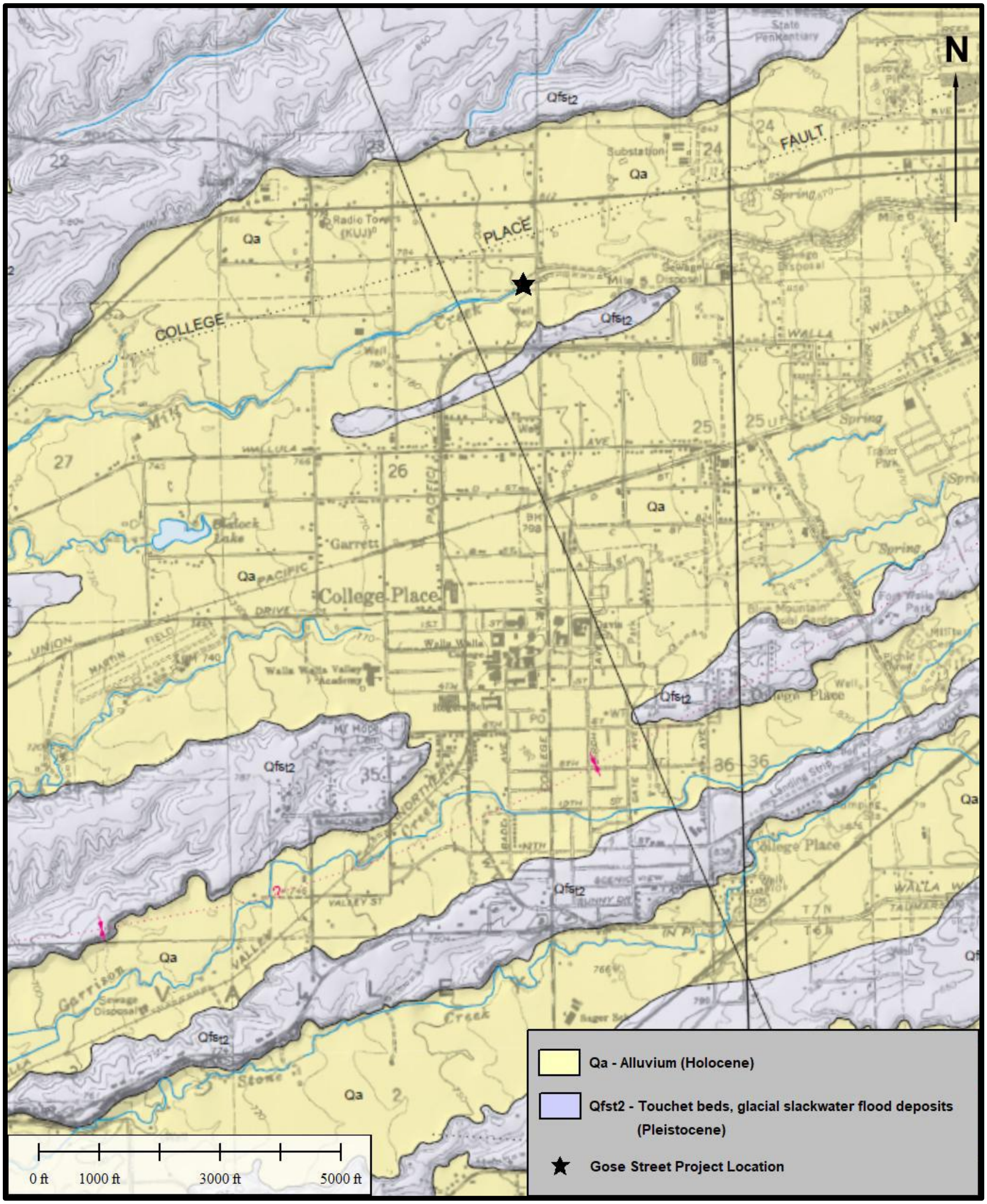
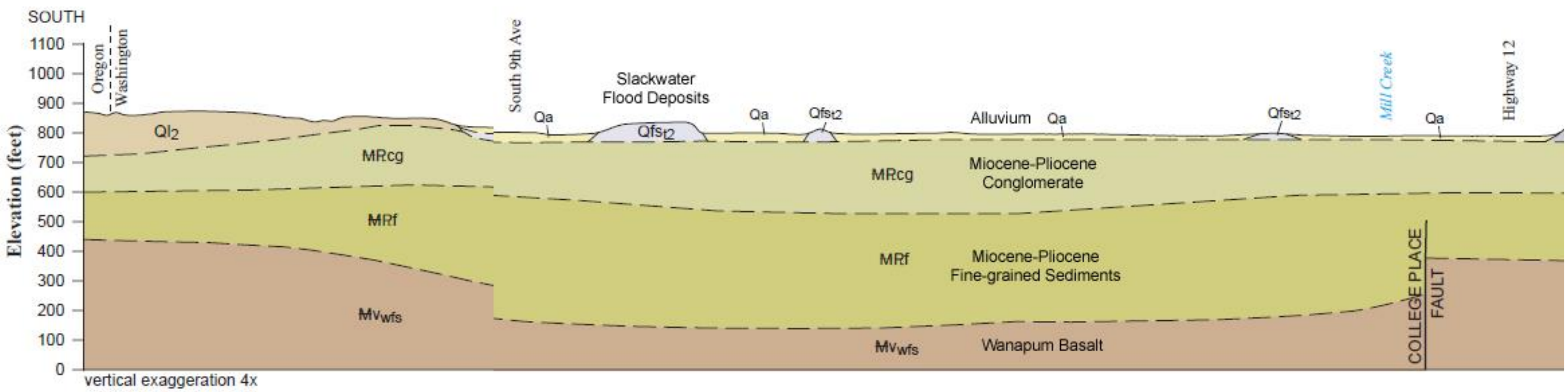



**Figure 2.** Geological map of Mill Creek and the Gose Street project area (Derkey et al. 2006).




*Adapted from Derkey et al. 2006 geological mapping*

Key: **Qa** – Alluvium
**Ql$_2$** – Loess
**Qfs$_{t2}$** – Glacial slack-water flood deposits
**MRcg** – Miocene- Pliocene conglomerate
**MRf** – Miocene-Pliocene fine-grained sediments
**Mv$_{wfs}$** – Wanapum basalt

**Figure 3.** Geological cross-section of the Walla Walla River valley and the Mill Creek project area (Derkey et al. 2006).

### *3.1 Historical Maps of Lower Mill Creek*

The earliest maps of the project area consist of General Land Office (GLO) plat map cadastral surveys from 1861 and 1867 (Figure 4). The GLO cadastral surveys defined the boundaries and sub-divisions of federal lands of the United States in preparation for settlement and governance. The GLO cadastral surveys focused on delineating section and parcel boundaries, so they often did not represent channel locations accurately within each section. Since no meander surveys were conducted to specifically identify the banks of Mill Creek, the surveyors simply sketched in the stream location based on observations between surveyed section boundaries. Most of the stream locations appear to be generally accurate, although some channel reaches erroneously cross through higher elevation Touchet beds or link up with the wrong distributary channels as evidenced by the topography shown on the LiDAR bare-earth DEMs.

The 1861 GLO survey notes describe Mill Creek as 12 links (8 feet) wide and 3 feet deep where it flowed between Sections 25 and 26 about 600 feet south of the current Gose Street crossing. The banks are "lined with cottonwood timber, willow bushes, and briars." There is no mention of any stream or channel features along the traverse between Sections 23 and 26. Mill Creek has an approximate width of 17 feet between the stream crossing of Sections 26 and 27 (just over a mile downstream from the Gose Street crossing) and Sections 27 and 28 about two miles downstream. The crossing between Sections 26 and 27 includes a description of brush that extends 2.75 chains (183 feet) on either side of the channel.

The other historical map of the Mill Creek area used in this assessment is the 1919 U.S. Geological Survey topographic map of the Walla Walla quadrangle (Figure 5). This is the first map to provide accurate elevations within the lower reach of Mill Creek. Mill Creek still has a multi-threaded channel east of town, but has lost some of its historical channel connections as it flows through the urbanized center of town. Outside of a mile-long split-channel reach in the western portion of the city, lower Mill Creek is shown as a single-threaded channel. The map shows Mill Creek with a meander bend to the north of the current channel just downstream of the Gose Street crossing. Overall, the map highlights the large amount of urban development that has occurred around the City of Walla Walla over the previous 50 years, but does not show the extent of agricultural development that also resulted in significant water withdrawals from streams, diversions of seeps and springs, and straightening of channels to control stream flows.

Finally, construction drawings from the Mill Creek flood control project in 1938 show that prior to the building of the weirs upstream of Gose Street, Mill Creek had a broad floodplain with a side channel that extended into the project reach (Figure 6). The overflow channel consists of two branches off the main channel that combine into one side channel heading southwest across the floodplain. The overflow channel area is uncultivated and considered wasteland. A small bridge is shown across Gose Street south of the main channel crossing with the overflow channel continuing westward. The survey does not extend much beyond the flood control district boundary at Gose Street, but does indicate that the floodplain in the project reach was frequently flooded and well-connected with the main Mill Creek channel.

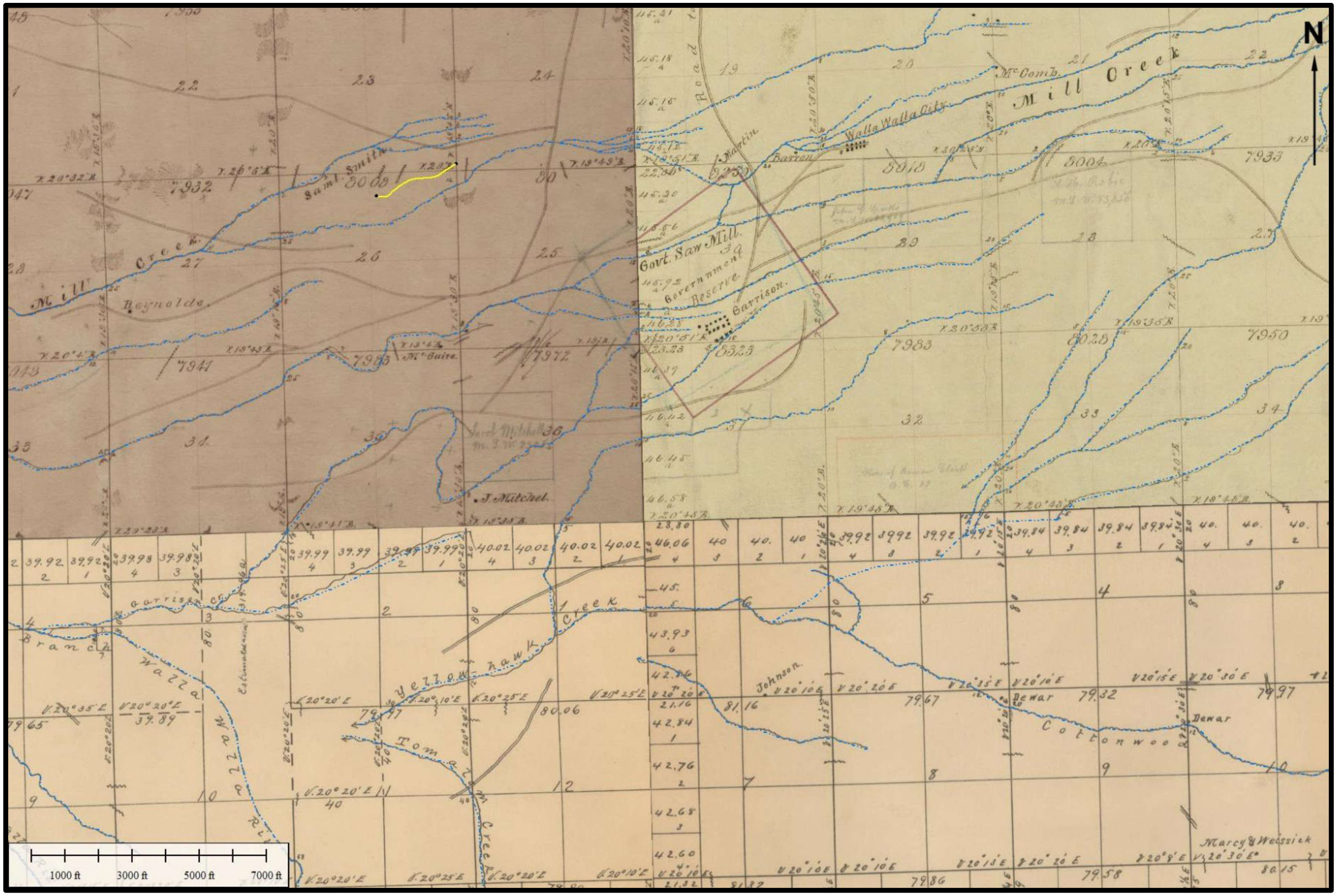



**Figure 4.** General Land Office (GLO) 1861 and 1867 plat map cadastral surveys of the lower Mill Creek basin highlighting the complex distributary channel network on the alluvial fan. *The Mill Creek project reach between the Gose and Hussey Street crossings is highlighted by the yellow line. The GLO streams have been enhanced with blue lines.*

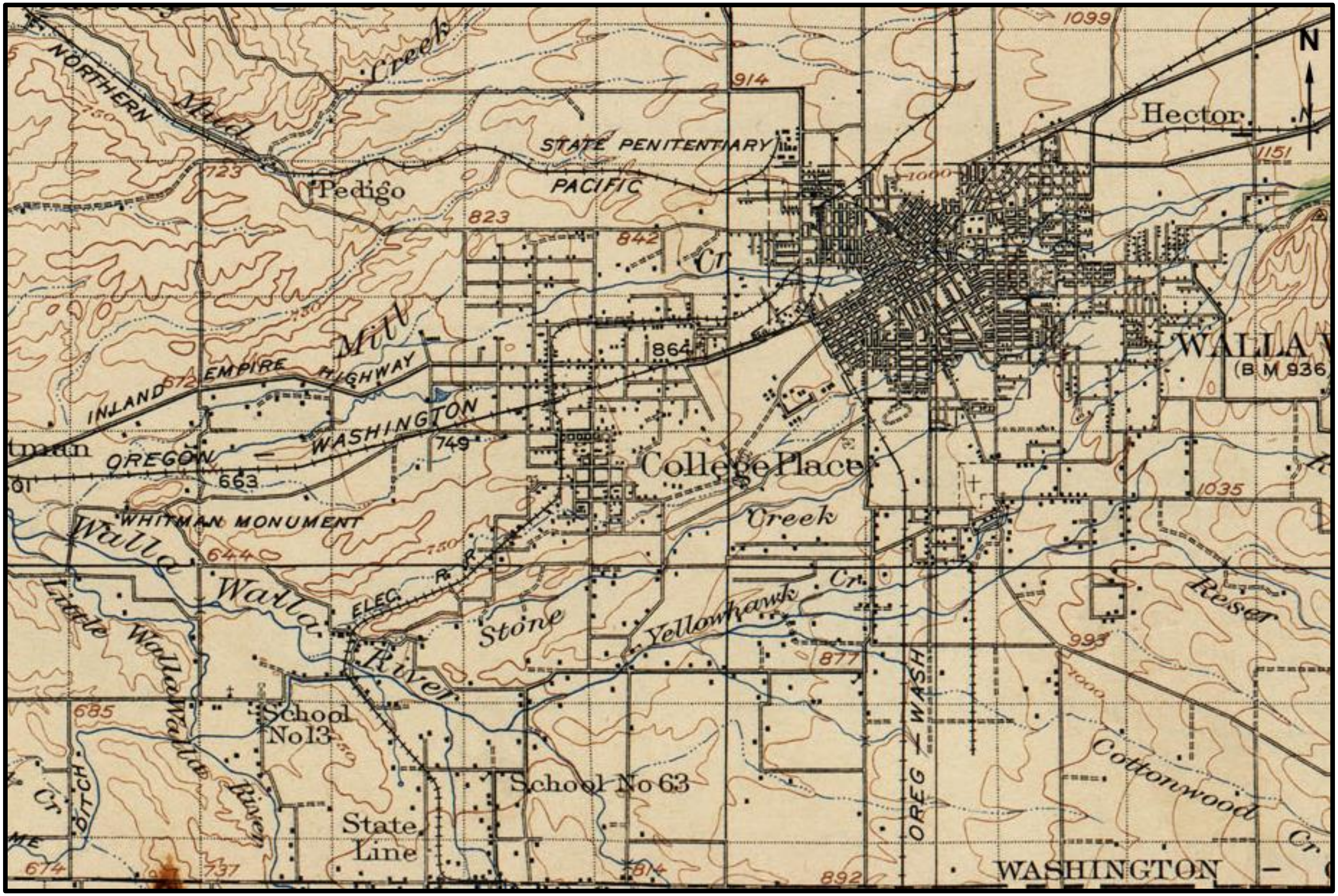



**Figure 5.** USGS 1919 topographic map of the lower Mill Creek basin prior to the construction of flood control structures.

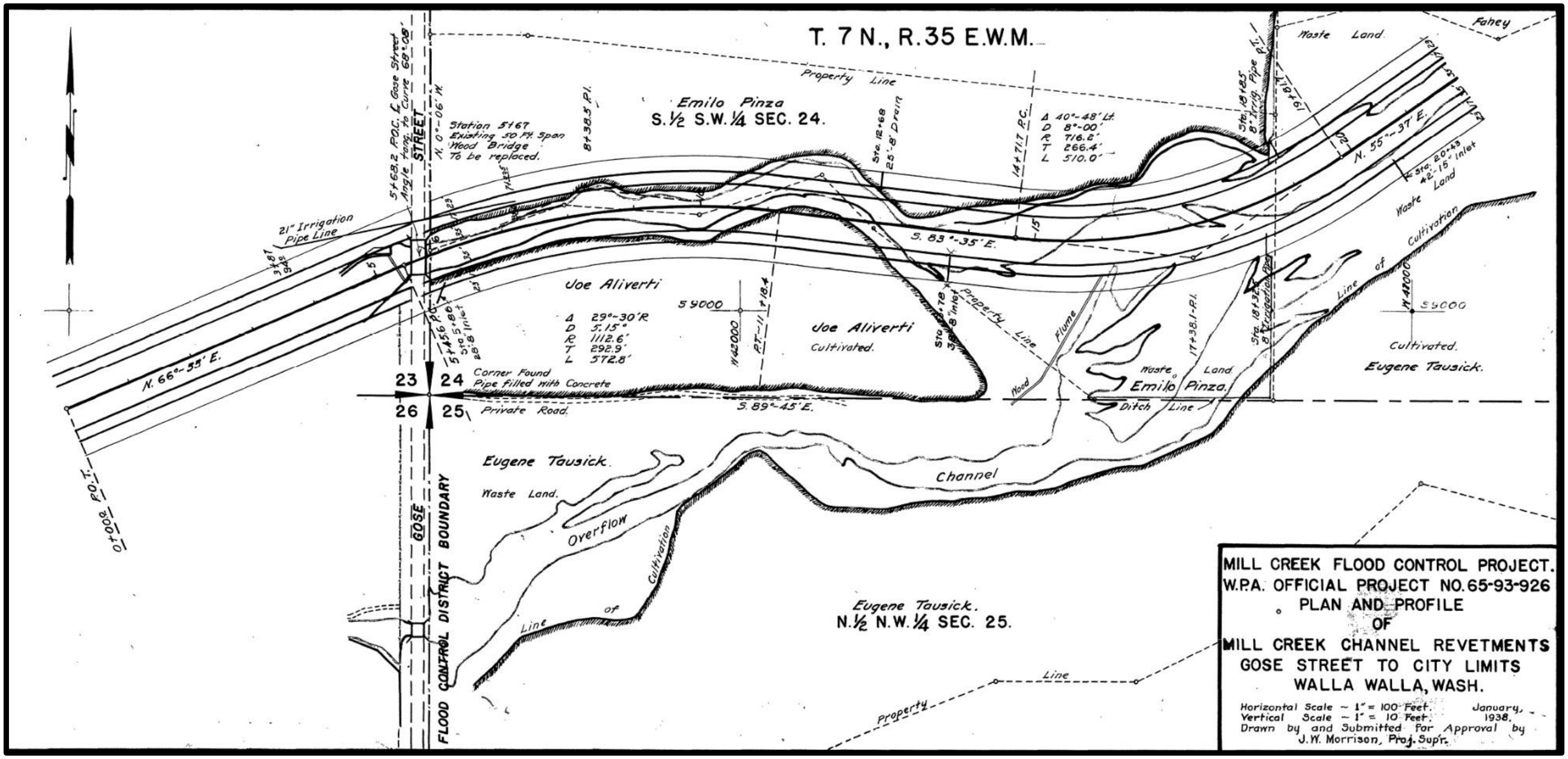



**Figure 6.** Plan view of Mill Creek upstream of the Gose Street crossing from a 1938 survey for the flood control project.

### *3.2 Historical Aerial Photographs*

To better assess the amount of channel migration within the Mill Creek project reach, historical aerial photographs from 1939 to 2021 were digitally rectified using Global Mapper geographic information system (GIS) software to accurately represent locations on a geographic datum (Table 1; Appendix A). Fixed points, such as roads and buildings, were used to accurately overlay the photographs. While the changes in channel location are generally accurate, some minor differences can be attributed to changes in canopy cover over time, the quality and scale of the air photos, and errors in rectifying the photos. air photos.

The earliest aerial photographs from 1939 are the only historical documentation of Mill Creek channel and floodplain conditions prior to construction of the flood control project during the 1940s (Figure 7). The area above the Gose Street crossing of Mill Creek closely matches the 1938 survey with unvegetated gravel bars around the two branches of the overflow channel. An island of cultivated fields can also be clearly seen between the mainstem and overflow channels, but a band of riparian vegetation is still present along most of the channel length. Downstream of the Gose Street crossing, the mainstem channel heads south for about 500 feet before flowing out onto a broad, largely unvegetated floodplain area approximately 800 feet in width. The mainstem channel becomes multi-threaded, and evidence of side channels and older channel scars can be seen in the largely uncultivated area (Figure 7). Mill Creek flows for about 1,500 feet through the broad channel migration zone before the channel becomes more confined and single-threaded. The active channel area narrows down to about 100 feet in width as it reaches the Hussey Street crossing. Overlaying the historical mapped channel locations with the 1939 aerial photographs highlights the broad expanse of floodplain occupied by Mill Creek and the high frequency of channel avulsions during this time (Figure 8). The high sediment load carried through this reach of Mill Creek is readily apparent in the broad area of unvegetated gravel bars at the overflow channel confluence upstream of the Gose Street crossing and the multi-threaded channel downstream of the crossing.

The next set of available aerial photographs for the Mill Creek project reach are from 1952 and 1957 (Figure 9). The 1952 aerial photograph shows the completion of the flood control project with a concrete-lined channel and series of weirs upstream from the Gose Street crossing. A vegetated remnant of the overflow channel can be still be seen along the southern edge of the channel migration area above the crossing. The downstream reach still follows much the same path as in 1939, but cultivated fields have begun to encroach on both the northern and southern portions of the channel migration area. By 1957, the Mill Creek channel has cutoff the southern meander bend below the Gose Street crossing and flows straight into the broader floodplain area (Figure 9). Channel scars are still present on the floodplain, but the previous complex channel pattern has already become simplified.

The 1964 aerial photograph shows continued channel shifting in the downstream portion of the broad floodplain area, but the upstream portion of the Mill Creek channel has not moved at all (Figure 10). The area of cultivation has also continued to encroach upon the historical channel

| Date | Scale | Flight Line and Negative Number |
|---|---|---|
| 1939 | 1:8,000[1] | WCMss.066 4-4 to 4-6[2] |
| 1952 | 1:70,000 | VV ASM 13AMS 1611 |
| 1957 | 1:49,000 | GS-VRG 1-45 |
| 1964 | 1:22,000 | GS-VAQQ 2-37 and 2-75 |
| 1976 | 1:78,000 | GS-VEGI 1-68 |
| 1982 | 1:58,000 | HAP 82 461813 247-204 (Infrared) |
| 1996 | 1:12,000 | College Place Quadrangle NAPP 9272 127, 129 |
| 2006 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2009 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2011 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2013 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2015 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2017 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2019 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |
| 2021 | 1:12,000 | USDA NAIP Digital Orthophoto Quadrangle |

**Table 1.** Summary of historical aerial photographs used to evaluate changes in the Mill Creek project area.

[1] Exact scale of photographs is uncertain and was estimated using GIS software.
[2] Walla Walla photographs collection, Whitman College and Northwest Archives.

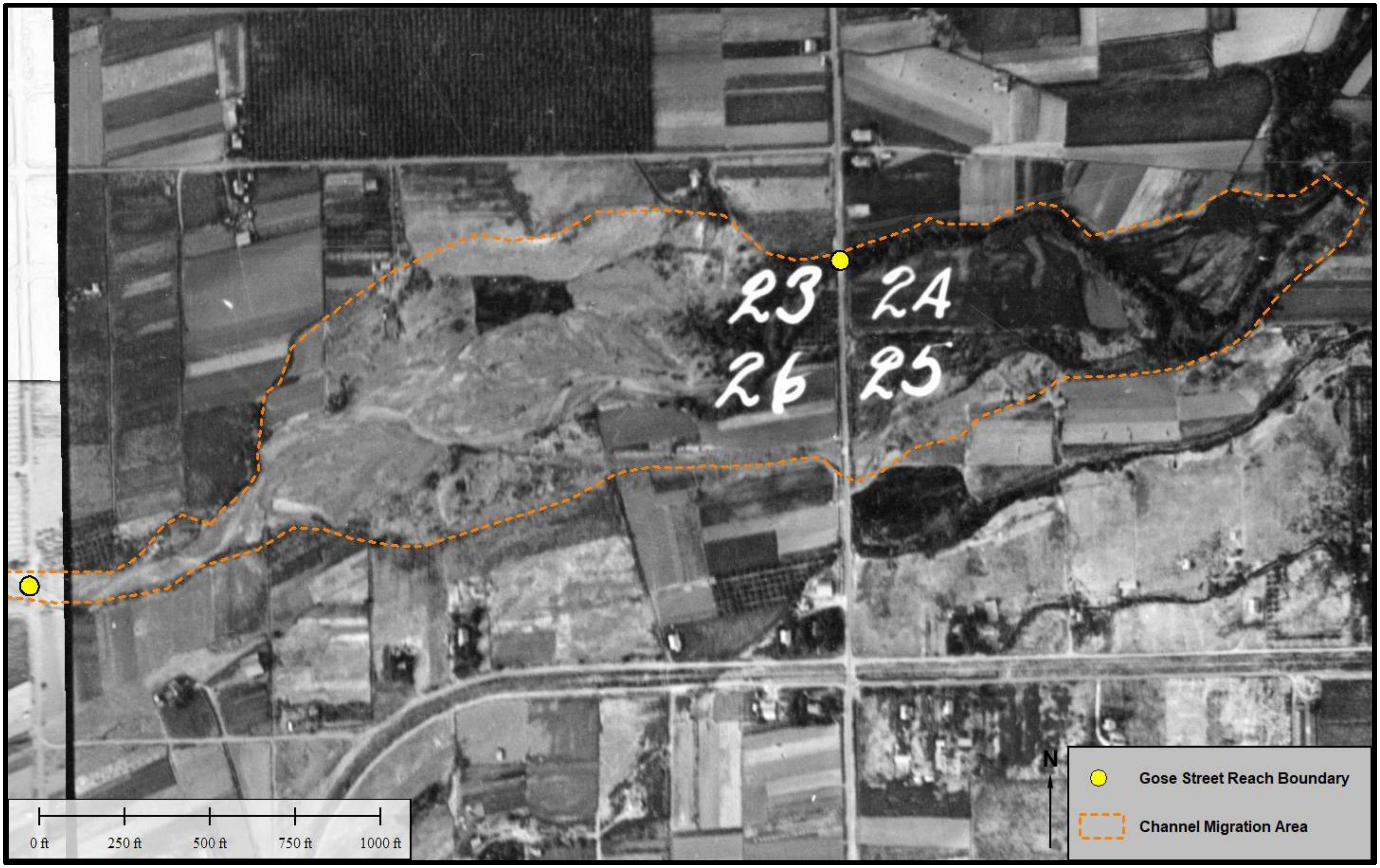
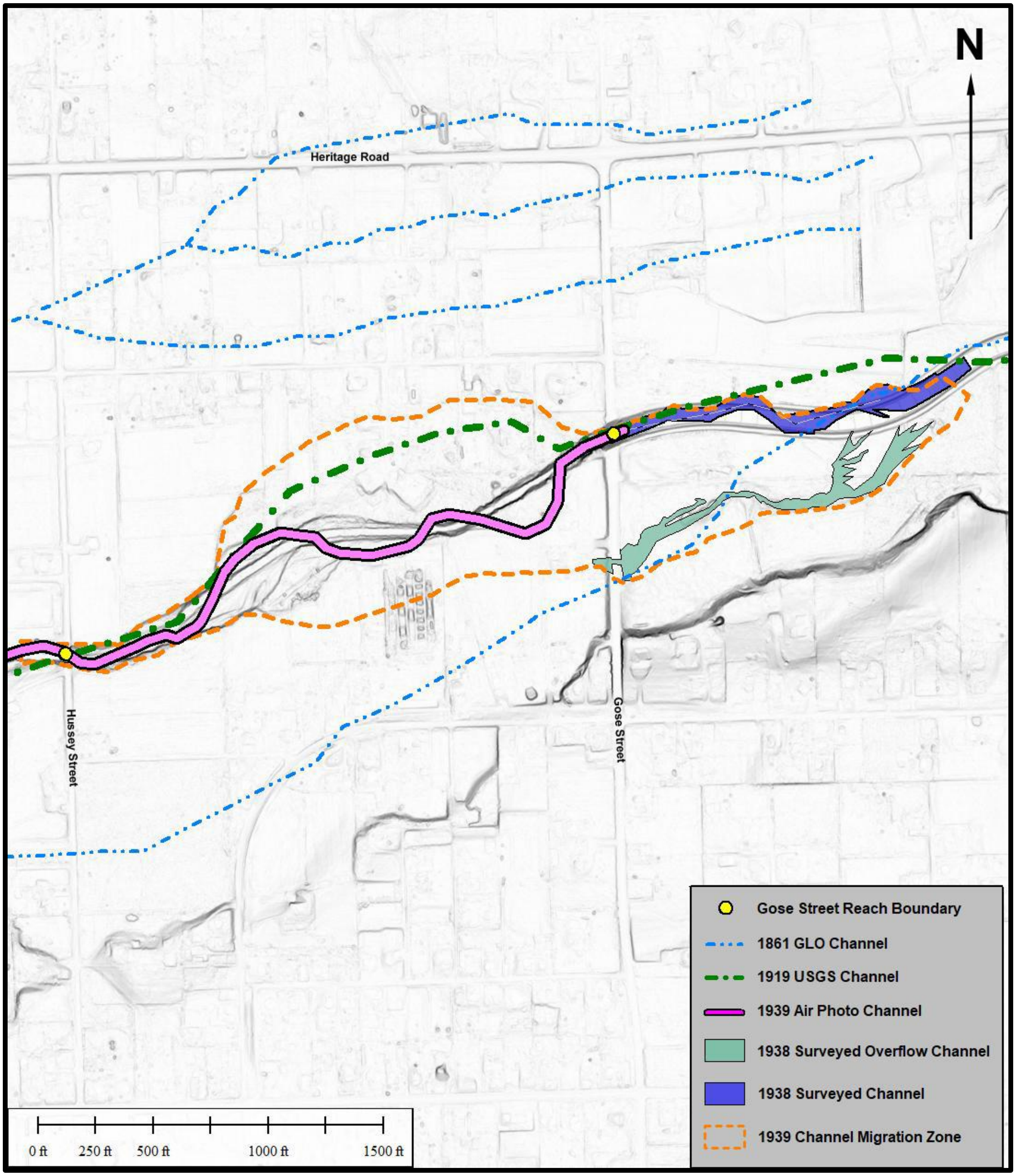



**Figure 7.** Aerial photograph from 1939 showing the Gose Street reach of Mill Creek and its channel migration area prior to construction of the flood control project.




*Shaded relief derived from 2018 U S. Geological Survey bare-earth LiDAR digital elevation model (DEM)*

**Figure 8.** Mill Creek channel locations prior to the construction of flood control structures.

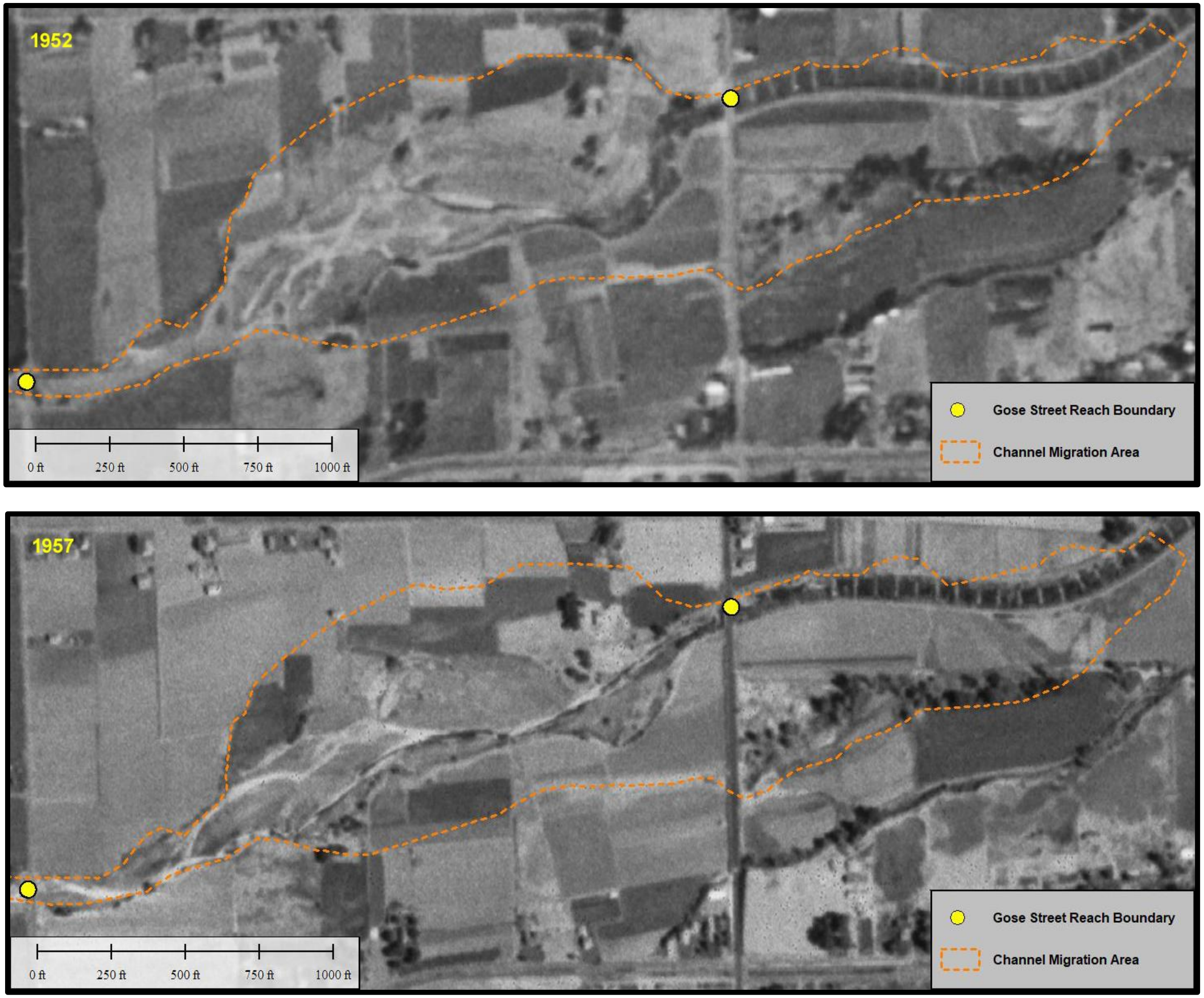



**Figure 9.** Aerial photographs from 1952 and 1957 of Mill Creek and its historical channel migration area in the Gose Street reach.

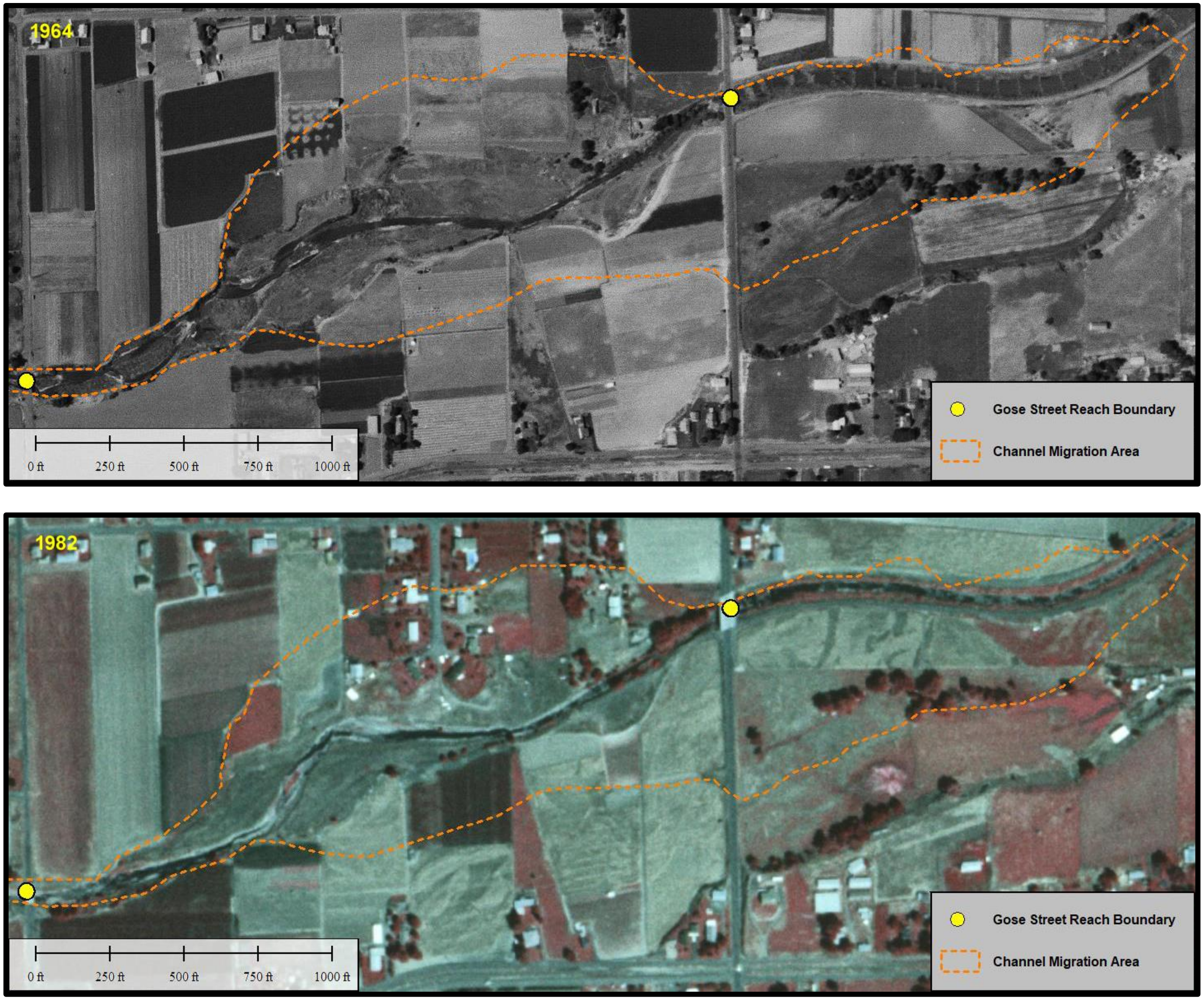



**Figure 10.** Aerial photographs from 1964 and 1982 of Mill Creek and its historical channel migration area in the Gose Street reach.

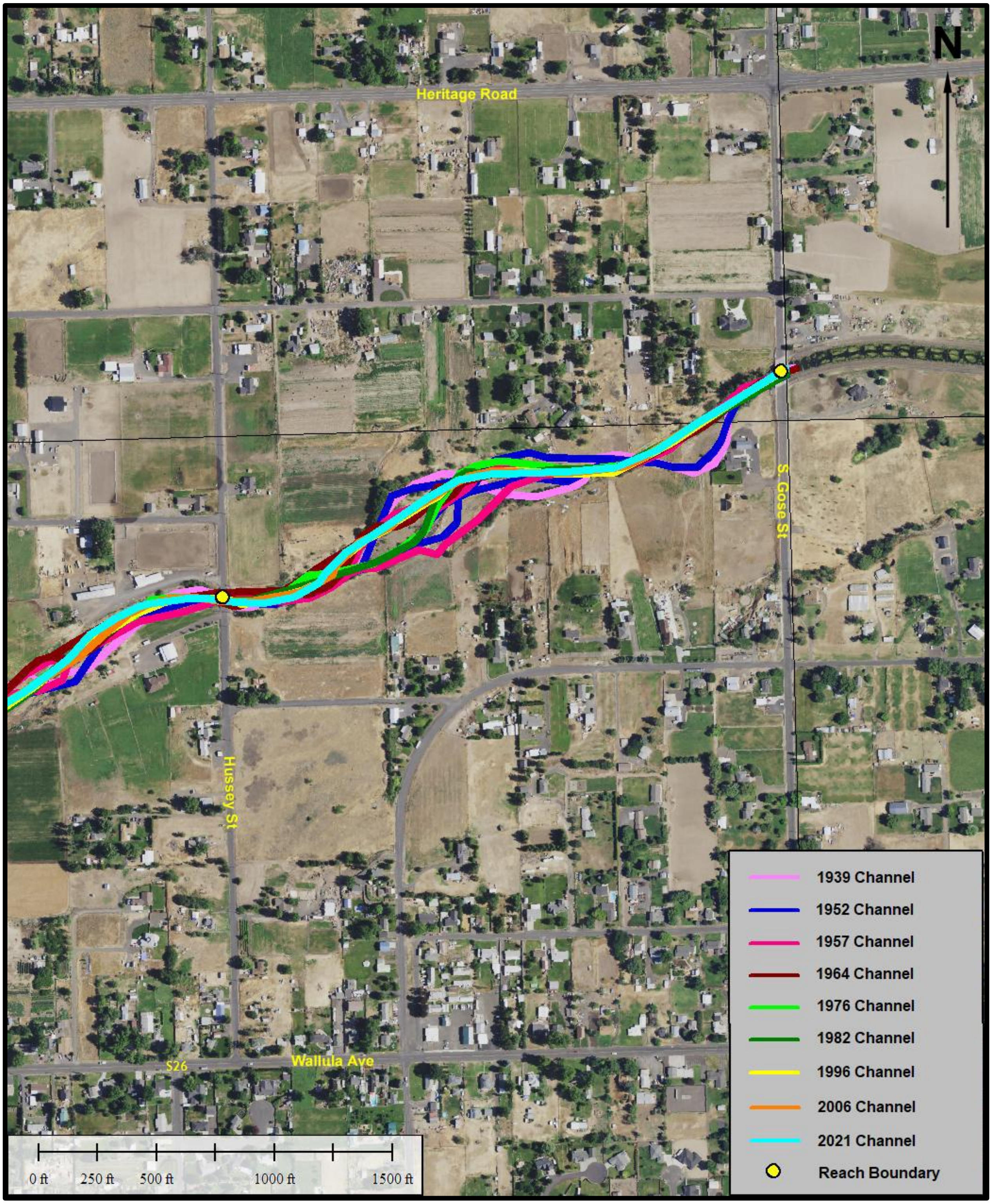
migration zone. The 1982 aerial photograph shows that another channel avulsion has occurred in the downstream portion of the broad flooplain area, but the old Mill Creek channel scars are no longer visible and urban development has encroached on the northern part of the former floodplain. A review of aerial photographs from 1996 through 2021 show that Mill Creek has become sufficiently incised within its former floodplain to no longer shift channel position. Figure 11 provides an overlay of Mill Creek channel locations from 1939 to 2021 to show the shift in channel pattern and to highlight the lack of channel migration over the past 25 years.

### *3.3 Mill Creek Flood History*

Between 1874 and 1931, Mill Creek flooded the town of Walla Walla approximately 15 times (Mitchell 2023). One of the earliest reported floods on Mill Creek occurred in 1906 when over 4 inches of rain fell during a 2-day period. The town of Walla Walla was flooded by up to a foot of water through the streets, but no streamflow measurements were taken so we do not know the actual peak discharge. Flood control efforts in the form of concrete levee bulkheads were installed at some locations, but high flows in 1920 and 1927 continued to cause damage in the town.

One of the largest floods on record in Mill Creek occurred from March 31 to April 2, 1931 and would be the impetus for local stakeholders and the U.S. Army Corps of Engineers to complete the Mill Creek flood control project more than a decade later. The flood was caused by a rain-on-snow event in early spring that involved significant precipitation (an estimated 6.65 inches) combined with snowmelt from warm winds that can produce substantial amounts of runoff over a short period of time. Again, no streamflow measurements were available to record the peak discharge. The cleanup took six months to complete and involved hauling away tons of debris and silt (Figure 12). A dredge was brought in to clear obstacles and excavate sediment from Mill Creek.

More recently, major floods have occurred in December 1964, February 1996, and February 2020 as shown on the peak flow graph (Figure 13). All of these major floods on Mill Creek can be attributed to rain-on-snow events that occur periodically about every 25 to 30 years. The February 2020 rain-on-snow event is the largest flood of record with about 7, 400 cfs at the stream gage above the flood control zone and 4,100 cfs running through the Mill Creek project reach at its peak. Over 8 inches of rain fell over a 60-hour period and the flood duration lasted about 48 hours (U.S. Army Corps of Engineers 2021).




*2021 USDA NAIP orthophotograph*

**Figure 11.** Mill Creek channel locations based on aerial photographs between 1939 and 2021.


**Figure 12.** Flood damage and sediment accumulation in the town of Walla Walla following the 1931 Mill Creek flood.

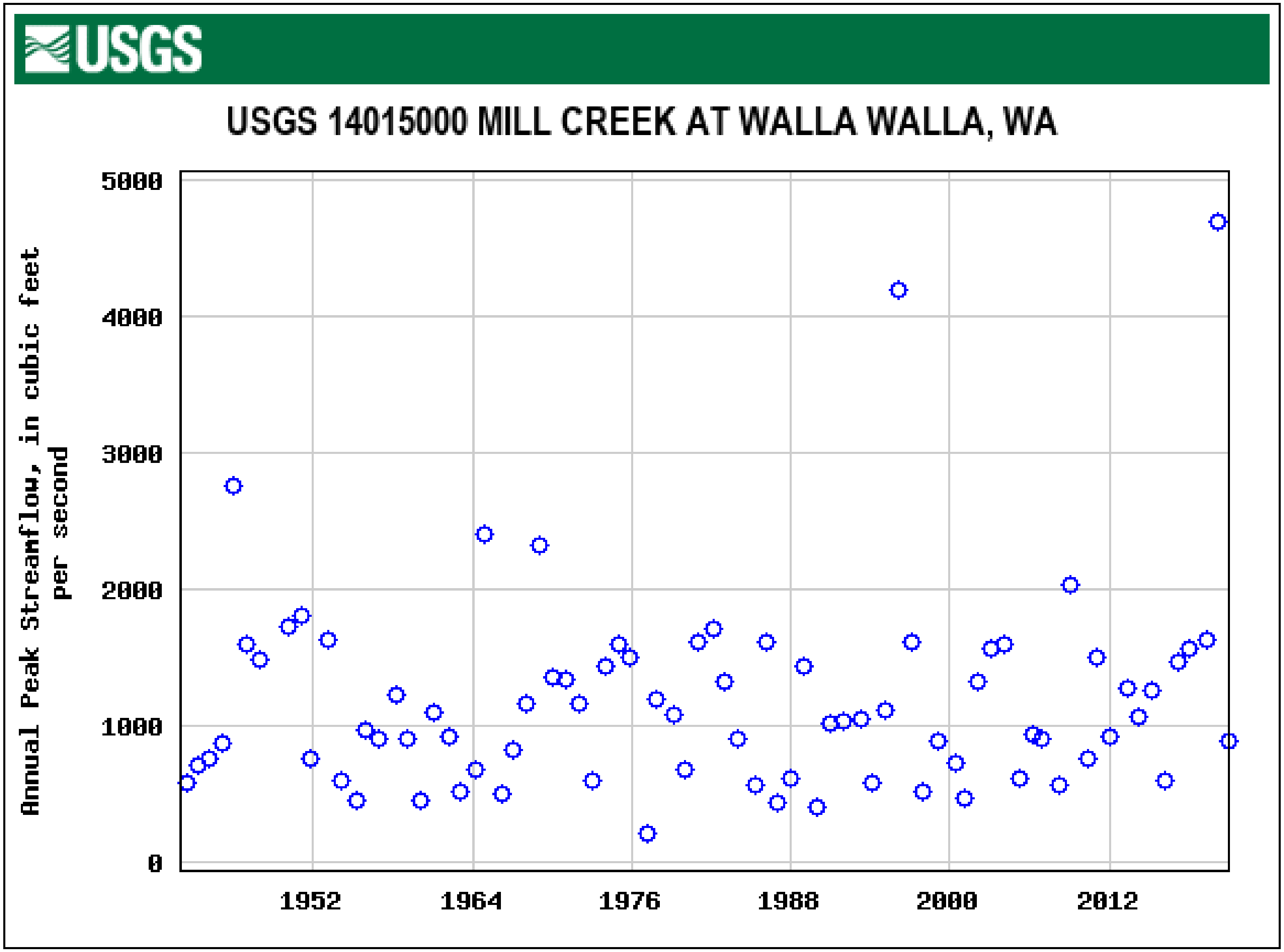



**Figure 13.** Mill Creek peak flow discharges from 1942 through 2021 at the eastern end of the City of Walla Walla.

# 4.0 Channel Incision in Lower Mill Creek

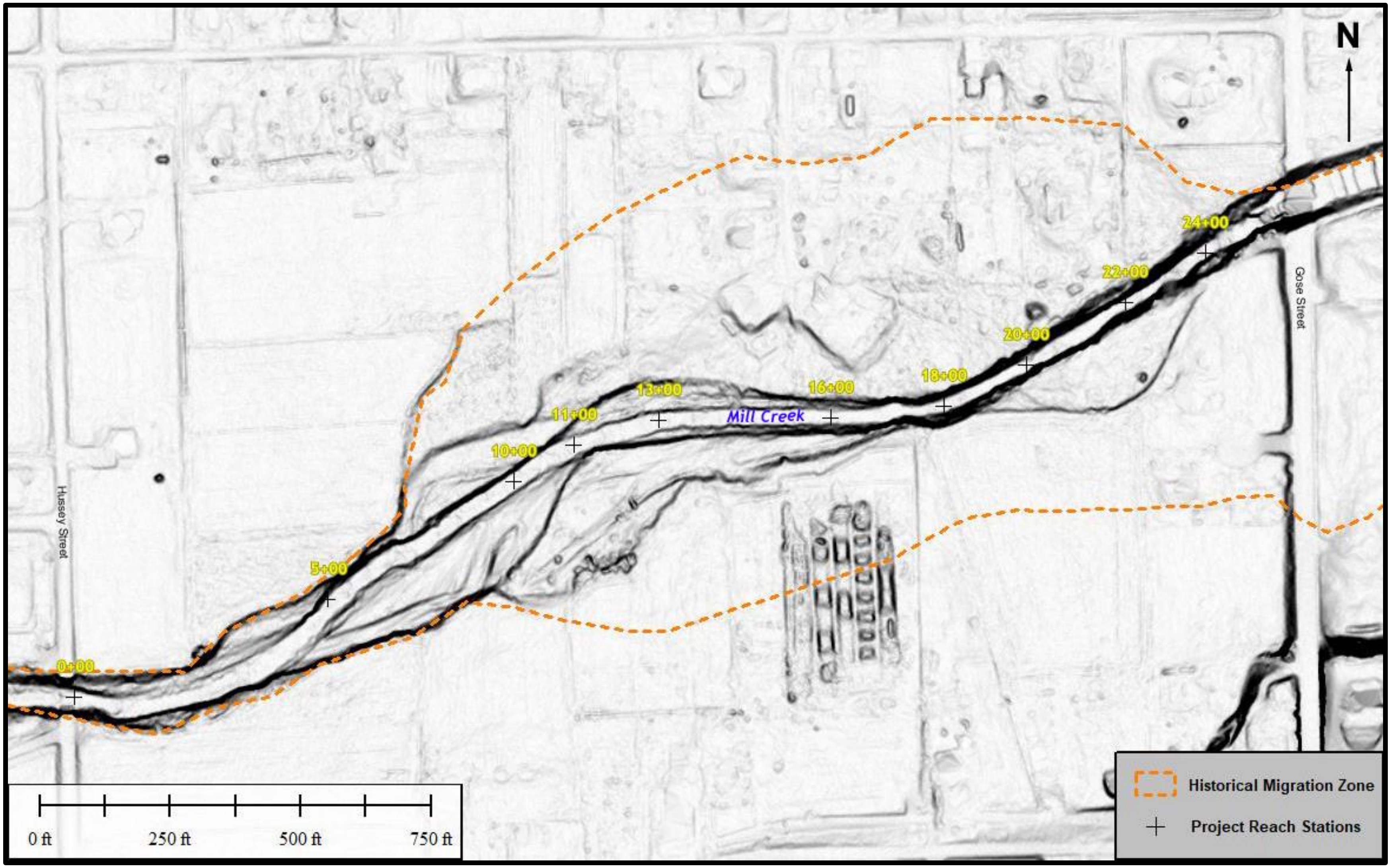
Upon completion of the flood control measures in the late 1940s, Mill Creek began flowing through a series of concrete-lined flumes and channel-spanning weirs for over 6.5 miles. The Bennington Diversion Dam located at RM 11.4, along with Division Works structures at RM 10.5, remove much of the sediment transported by the stream and reduce peak flows to minimize downstream flood damage. The Bennington Diversion Dam diverts flood water from Mill Creek into an 1,800-foot canal that flows into Bennington Lake. Bennington Lake is a 53-acre reservoir that can store up to 8,300 acre-feet of water that can be slowly released after the flood peak. From the Division Works structure at RM 10.5, Mill Creek flows through a concrete-lined channel and rip-rapped levees that are managed by the Mill Creek Flood Control Zone District down to the Gose Street crossing at RM 4.8.

Initially, the concrete pools and weirs at the Gose Street crossing transitioned directly into the existing channel. A new bridge was constructed in 1969 at Gose Street and an additional concrete weir and low flow channel were added below the bridge crossing. In response to channel incision at the transition area under the Gose Street bridge crossing, two concrete pool-and-chute fishways and concrete channel-spanning weirs were constructed in 2008 to help address fish passage issues in this reach of Mill Creek. An additional 4 to 5 feet of incision was documented below the fishway following the 2020 flood.

## *4.1 Current Geomorphic Conditions in the Gose Street Reach of Mill Creek*

The assessment of historical aerial maps and photographs show that Mill Creek has shifted from a multi-threaded, anastomosing channel pattern to a relatively straight and confined channel through the entire project reach. Lower Mill Creek historically had both single-threaded and multi-threaded reaches, but the current shift in channel pattern appears directly related to the concentration of streamflow through the flood control project and the loss of sediment transport from the upper reaches of Mill Creek. The bare-earth LiDAR digital elevation models show the current channel pattern and highlight older terraces and floodplain areas that have been abandoned by Mill Creek as channel incision has increased (Figure 14).

The current Mill Creek channel below the concrete fishway is tightly confined by cemented conglomerate banks about 20 feet in height (Figure 15). The top of the steep banks is well vegetated with a dense canopy cover along the first 300 feet of the stream below the fishway. The vegetation includes willow and blackberry shrubs. The channel bed is composed of cemented conglomerate and contains very little loose substrate. Chunks of conglomerate, old rip-rap, and concrete have been deposited along the edge of the channel. Portions of the north bank have been undercut by several feet (Figure 16). Lenses of sand and silt in the conglomerate stratigraphy may be preferentially prone to erosion and lead to the undercut banks. Small groundwater seeps were also observed along the south bank of the stream. The channel remains tightly confined for another 400 feet beyond the denser vegetation and is generally unshaded by an overstory canopy. The banks are dominated by grasses and patches of reed canary grass.




*Shaded relief derived from 2018 U S. Geological Survey bare-earth LiDAR digital elevation model (DEM)*

**Figure 14.** High-resolution LiDAR bare-earth shaded relief map of the Mill Creek Gose Street project reach.


**Figure 15.** Mill Creek looking upstream and downstream below the concrete fishway.

**Figure 16.** Undercut banks and lenses of sand and silt within the conglomerate of Mill Creek.

As Mill Creek bends to the west, the channel and floodplain area widen, but the channel remains tightly confined by the conglomerate banks (Figure 17). A narrow band of more resistant conglomerate may be responsible for the small knickpoint with a 2- to 3-foot drop into the plunge pool below or it may represent a mobile knickpoint as channel incision propagates upstream. The channel narrows beyond the pool area and bends to the southwest before approaching the Hussey Street crossing. Most of the channel area is unvegetated with only grass and small shrubs on the banks of the stream. The banks are about 15 feet high and still largely composed of cemented conglomerate. The top 3 to 5 feet of the bank consists of rounded gravel and cobble along with sand and silt from younger alluvial deposits. The younger alluvial deposits are unconsolidated and do not show the oxidation and weathering seen in the clasts of the older cemented conglomerate. (Figure 18). The former floodplain on the north bank now consists of residential development and shows the extent to which the former floodplain has been disconnected from high flows in Mill Creek.

Mill Creek becomes confined by floodplain terraces as it bends to the southwest (Figure 19). The channel edge includes small boulders and chunks of concrete, but no gravel bars are present. Very little vegetation is present along the channel, except for grasses and small shrubs. Two older floodplain terraces were observed on the left bank of the channel, with a corresponding floodplain terrace on the right bank of the channel. The channel bends back to the west as it approaches the Hussey Street crossing (Figure 19). The channel is well confined by cemented conglomerate banks that are about 10 feet high. The right bank includes more shrubby vegetation and reed canary grass, while the left bank includes some willow shrubs. Concrete rubble and old angular rip-rap boulders are present in the channel, but the channel bed still consists primarily of cemented conglomerate.

Almost no substrate is present in the Mill Creek project reach, except for small amounts of cobble and gravel from eroded conglomerate. The combination of Bennington Dam and the sediment retention weirs in the upper reaches of the flood control project effectively prevent any coarse sediment from being transported to the lower reaches of Mill Creek. Since the channel in the project reach has almost no sediment input or storage potential, there is little value in constructing a sediment budget. Any sediment that makes it into the project reach will be quickly transported out during larger flood flows. The hydraulic forces within the confined channel are too high to retain sediment and continued incision is likely to occur, particularly during larger floods.

**Figure 17.** Start of wider channel area and resistant conglomerate knickpoint on Mill Creek.



**Figure 18.** Alluvial deposits and former floodplain height on Mill Creek.

**Figure 19.** Looking downstream as Mill Creek flows toward the southwest and looking upstream from the Hussey Street bridge at the meander bend where the stream flows west.

## *4.2 Channel Incision Rates in the Gose Street Reach of Mill Creek*

Tetra Tech (2017) produced longitudinal profiles of Mill Creek using the 1919 U.S. Geological Survey topographic survey and more recent topographic data (Figure 20). The profile clearly shows an abrupt drop in channel elevation at the Gose Street crossing relative to historical conditions. The channel incision continues down to the Wallula Avenue crossing of Mill Creek, but then channel aggradation begins to occur around the Last Chance Road crossing. The 1919 channel profile shows a natural inflection in stream gradient at the Gose Street crossing. The lower stream gradient downstream from Gose Street would have encouraged greater sediment deposition and likely accounts for the historically broad floodplain and channel migration area in much of the project reach. The Mill Creek channel likely narrowed to a single-threaded channel at the Hussey Street crossing just beyond the broad area of sediment deposition, but was still well connected with the floodplain as evidenced by several distributary channels on the floodplain that can still be seen on the LiDAR digital elevation models (DEMs).

To help quantify the amount of channel incision within the project reach, past locations of Mill Creek identified from the historical aerial photographs were compared with 2021 topographic surveys and 2018 bare-earth LiDAR DEMs to estimate the channel bed elevation during that time. For example, the 1939 and 1952 aerial photographs show that Mill Creek had a well-defined meander bend downstream from the Gose Street crossing around Station 22+00. The current terrace elevation is approximately 800 feet and is considered the channel bed elevation in 1952. The 2018 bare-earth LiDAR indicates a channel bed elevation of 785 feet, while the 2021 survey shows the current bed elevations at 780 feet. This data show that 20 feet of incision has occurred through the straight reach of Mill Creek below the fishway at the Gose Street crossing since the 1950s.

As the stream enters the wide floodplain reach at about Station 20+00, the 1952 aerial photograph shows Mill Creek flowing on the right bank floodplain surface. The current elevation of the floodplain terrace at Station 15+00 is approximately 791 feet. The 2018 bare-earth LiDAR indicates a channel bed elevation of 781 feet, while the 2021 survey shows current bed elevations at 776 feet. About 15 feet of incision has occurred at this point relative to historical conditions. The lower end of the wide floodplain area at Station 9+00 has another terrace on the right bank where Mill Creek was located in 1952 at an elevation of 785 feet (Figure 21). The 2018 bare-earth LiDAR indicates a channel bed elevation of 776 feet, while the 2021 survey shows current bed elevations at 772 feet. About 13 feet of incision has occurred at this point relative to historical conditions.

A few hundred feet below the Hussey Street crossing, the 1952 and 1957 aerial photographs show that Mill Creek splits into two channels on a small terrace on the left bank of the stream. The terrace surface is at approximately 770 feet in elevation. The 2018 bare-earth LiDAR indicates a channel bed elevation of 763 feet. The 2021 survey did not extend beyond Hussey Street, but based on the upstream incision following the 2020 flood, this site likely experienced an additional 3 feet of channel incision. Overall, Mill Creek below the Hussey Street crossing has likely had 7 to 10 feet of incision since the 1950s.

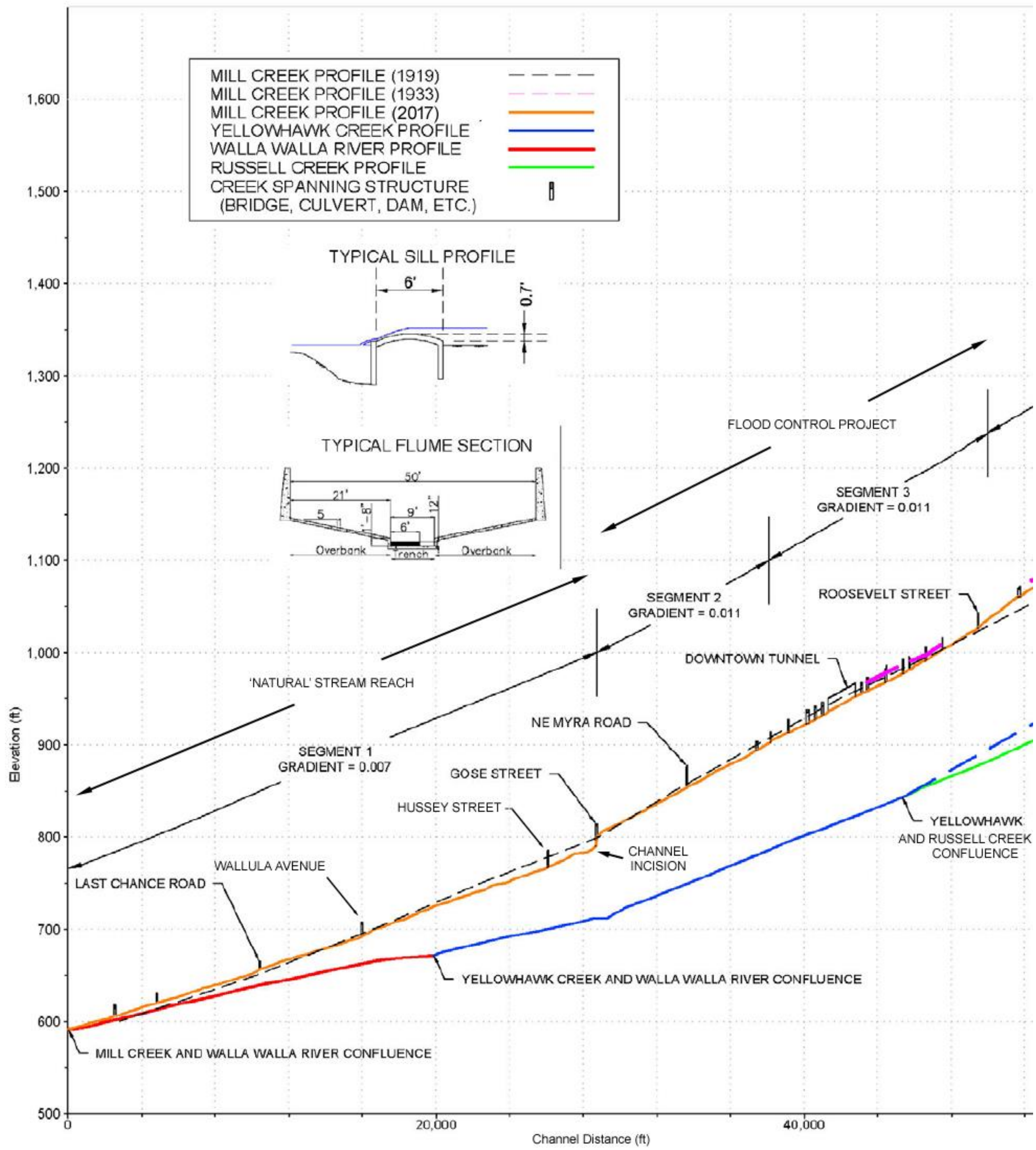



**Figure 20.** Mill Creek longitudinal profile highlighting channel incision since 1919 between the Gose and Hussey Street crossing (adapted from Tetra Tech 2017).

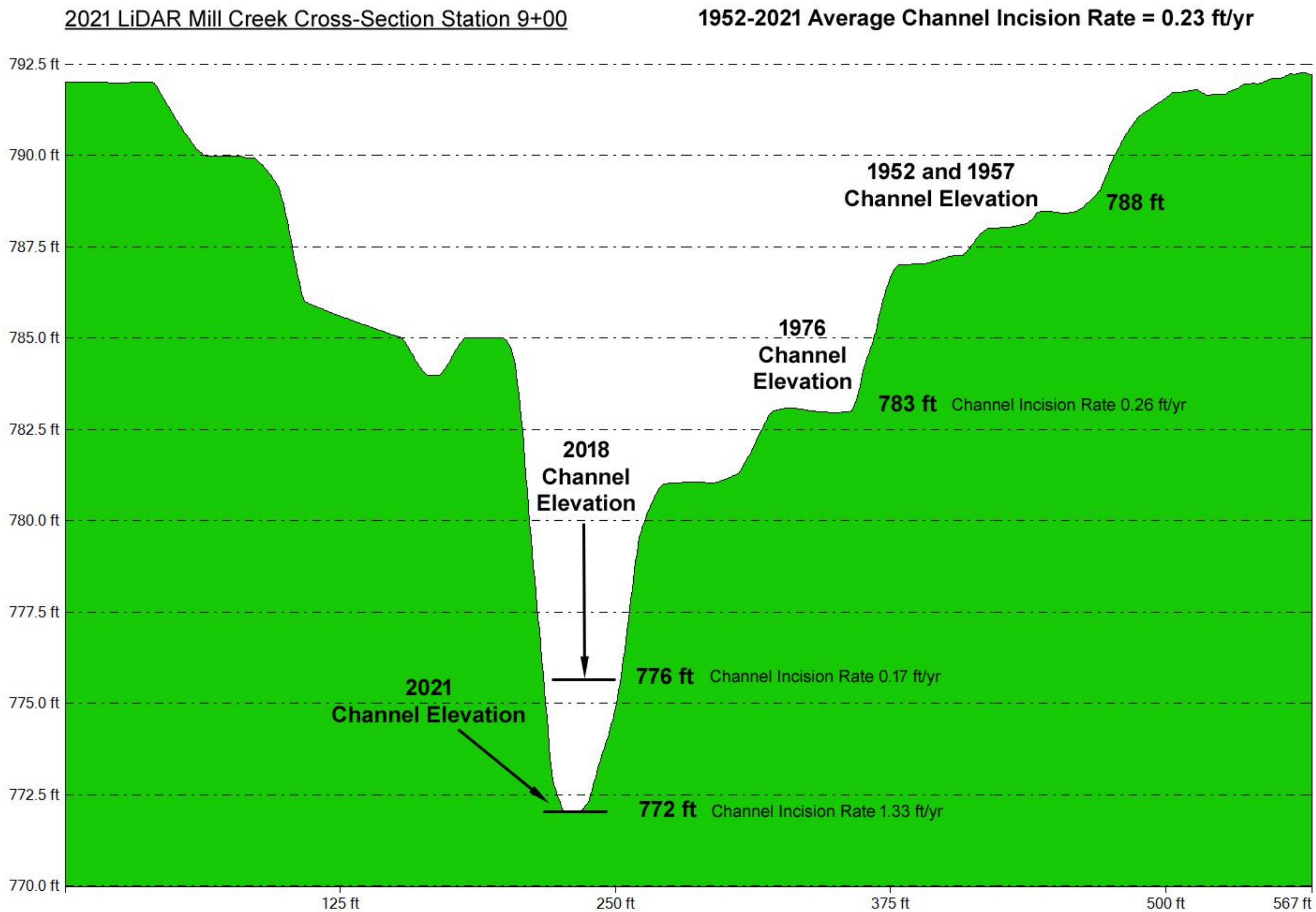



**Figure 21.** Historical channel elevations and incision rates for Mill Creek from 1952 through 2021 at Station 9+00.

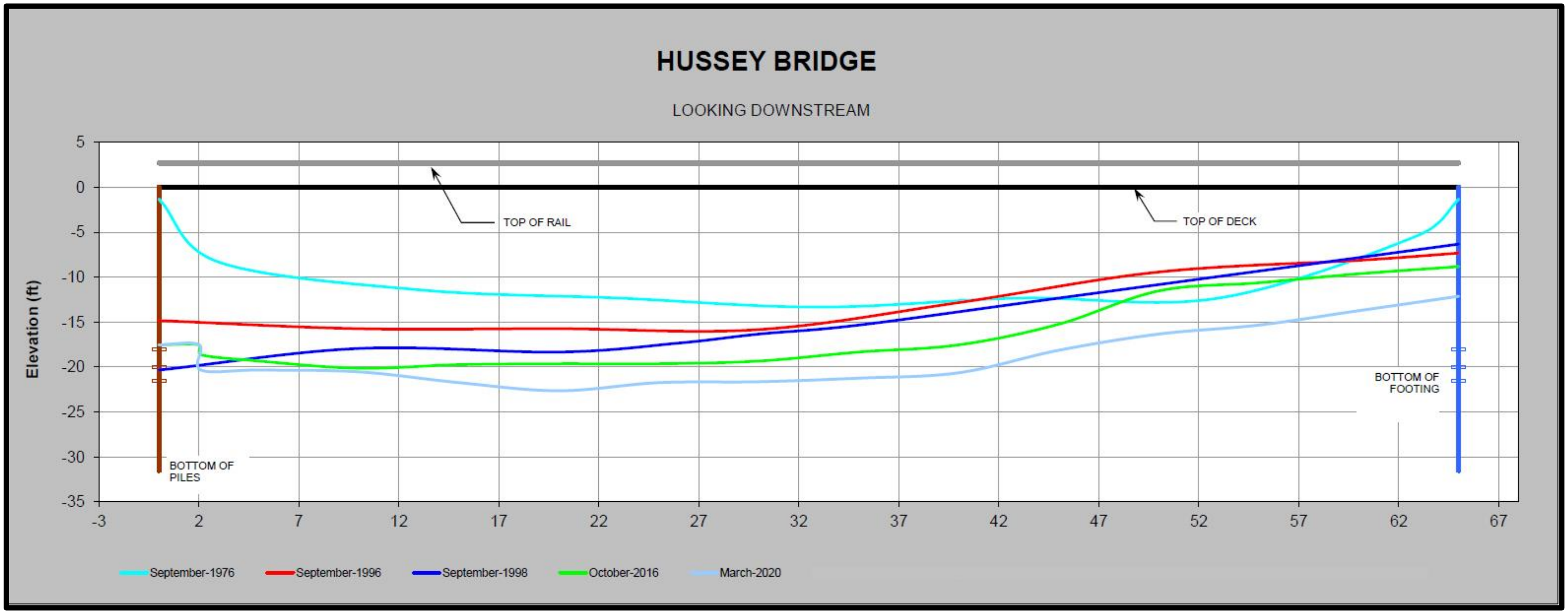
Historical cross-sections of Mill Creek at the Hussey Creek bridge compiled by Walla Walla County provide a similar estimate of channel incision between 1976 and 2020 (Figure 22). A 1976 channel survey provided cross-sectional bed elevations just after the bridge was constructed. The channel bed elevations at that time generally ranged from 10 to 14 feet below the bridge deck. The latest cross-sectional survey from 2020 had channel bed elevations of 20 to 23 feet below the bridge deck, suggesting that 8 to 10 feet of incision has occurred over the 44 years of survey record.

Finally, Federal Emergency Management Agency (FEMA) national flood insurance provides another estimate of channel incision in Mill Creek (FEMA 1983). FEMA compiled water elevation profiles for varying flood recurrence intervals on lower Mill Creek based on surveyed streambed elevations and cross-sections measured in 1983. Using the data from cross-sectional locations within the project reach at about Station 11+00 and Station 22+00, the average channel incision between 1983 and 2021 was estimated to be 6 feet.

Table 2 summarizes the Mill Creek channel incision rate within the project reach based on the various methods described in this report. The upstream part of the project reach between Station 20+00 and 24+00 has experienced the greatest amount of incision since the flood control project was constructed and appears to have an annual incision rate of almost 0.3 feet per year. The middle and lower portions of the project reach have had an estimated 8 to 13 feet of channel incision since the 1950s and have an incision rate of around 0.2 feet per year. The 4 to 5 feet of incision measured after the 2020 flood suggests that large floods may play a disproportionately greater role in causing degradation of the channel than the mean annual or 2-year recurrence flows that typically shape channel morphology. A longitudinal profile of the Mill Creek streambed elevation at various dates has been created to help illustrate the amount of channel incision over time (Figure 23).

| Location | Methodology | Data Range | Incision Depth (ft) | Time Frame (yr) | Incision Rate (ft/yr) |
|---|---|---|---|---|---|
| Station 22+00 | Aerial photographs and LiDAR DEMs | 1952-2021 | 20 | 69 | 0.29 |
| Station 9+00 | Aerial photographs and LiDAR DEMs | 1952-1976 | 5 | 24 | 0.26 |
| Station 9+00 | Aerial photographs and LiDAR DEMs | 1976-2018 | 7 | 42 | 0.17 |
| Station 9+00 | Aerial photographs and LiDAR DEMs | 2018-2021 | 4 | 3 | 1.33 |
| Station 9+00: | Aerial photographs and LiDAR DEMs | 1952-2021 | 16 | 69 | 0.23 |
| Hussey Street Bridge | Surveyed Cross-Sections | 1976-2020 | 8 | 44 | 0.18 |
| Station 11+00 Station 22+00 | Surveyed Cross-Sections and LiDAR DEMs | 1983-2021 | 6 | 38 | 0.16 |

**Table 2.** Summary of channel incision rates estimated for the Mill Creek project reach.




*Data collected by Walla Walla County Department of Public Works*

**Figure 22.** Historical cross-sections of Mill Creek from 1976 through 2020 at the Hussey Street bridge crossing.

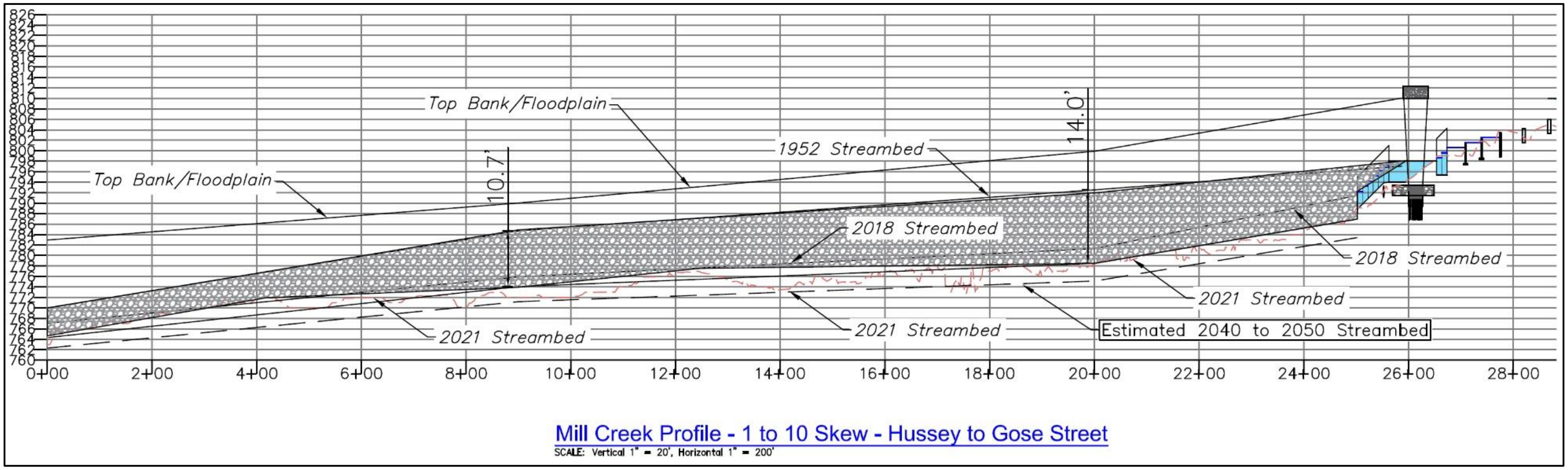



**Figure 23.** Longitudinal profile of Mill Creek streambed elevations from 1952 through 2050 in the Gose Street project reach.

# 5.0 Implication of Channel Incision on Restoration of Fish Passage in Lower Mill Creek

During high flows, Mill Creek historically spread out into multiple distributary channels and broad floodplain areas upstream of the Hussey Road crossing. In addition, Mill Creek had a significant amount of hydraulic roughness from bedload transport, in-channel large woody debris, and riparian vegetation along stream banks that reduced the erosive power of flood flows. The current conditions in the flood control zone district concentrates and efficiently transports water through the system with a lack of bedload transport and little hydraulic roughness to reduce the stream power. Coarse sediment is removed periodically above Bennington Dam and from a 400-foot-wide reach downstream of Tausik Way. While Bennington Dam reduces the largest peak flows in Mill Creek, the more frequent 2-year recurrence interval channel-forming flows as well as larger flood flows are likely sufficient to mobilize sediment and cause channel incision.

Channel incision results from an imbalance in the power available to transport sediment versus the amount of power necessary to move sediment within the reach. When the sediment transport capacity exceeds the sediment supply, erosion of the bed or banks will occur. Where banks are cohesive and resistant to erosion, such as the cemented conglomerate in Mill Creek, bed erosion is typically dominant over channel widening. As incision increases and higher and higher flows are maintained within its banks, a positive feedback loop can occur where shear stress on the bed and toe of the banks is increased over time.

Mill Creek is still actively downcutting within the project reach and is likely to continue downcutting for many decades, if not centuries, unless interventions are made to arrest the channel incision. The strength and cohesiveness of the cemented conglomerate provides significant resistance to channel widening and promotes degradation of the channel bed. Without any interventions, the Gose Street project reach will likely take many centuries to reach any sort of quasi-equilibrium in the channel. The channel may be disproportionally impacted by larger floods that can pluck out gravel more effectively from the cemented conglomerate as high pore-water pressures loosen the fine sandy matrix surrounding the larger substrate. Further assessment of the conglomerate and its propensity for erosion would need to be undertaken to better understand the mechanism for substrate detachment and the likelihood of changes in the future rates of channel incision.

Channel evolution models (Schumm 1977; Schumm et al. 1984; Cluer and Thorne 2014) have been created to help identify different stages of channel development after incision has begun and to correlate benefits for aquatic habitat (Watson et al. 2002). Incised channels typically follow a step-wise process of 1) degradation, 2) widening, 3) aggradation, and 4) development of a new quasi-equilibrium in sediment supply and transport as a new floodplain develops over time (Figure 24). Cluer and Thorne (2014) have expanded on the channel evolution model and characterize the channel evolution as a cycle that can have variable benefits to biota at different stages (Figure 25 and Figure 26). The highest aquatic habitat benefits are achieved when the

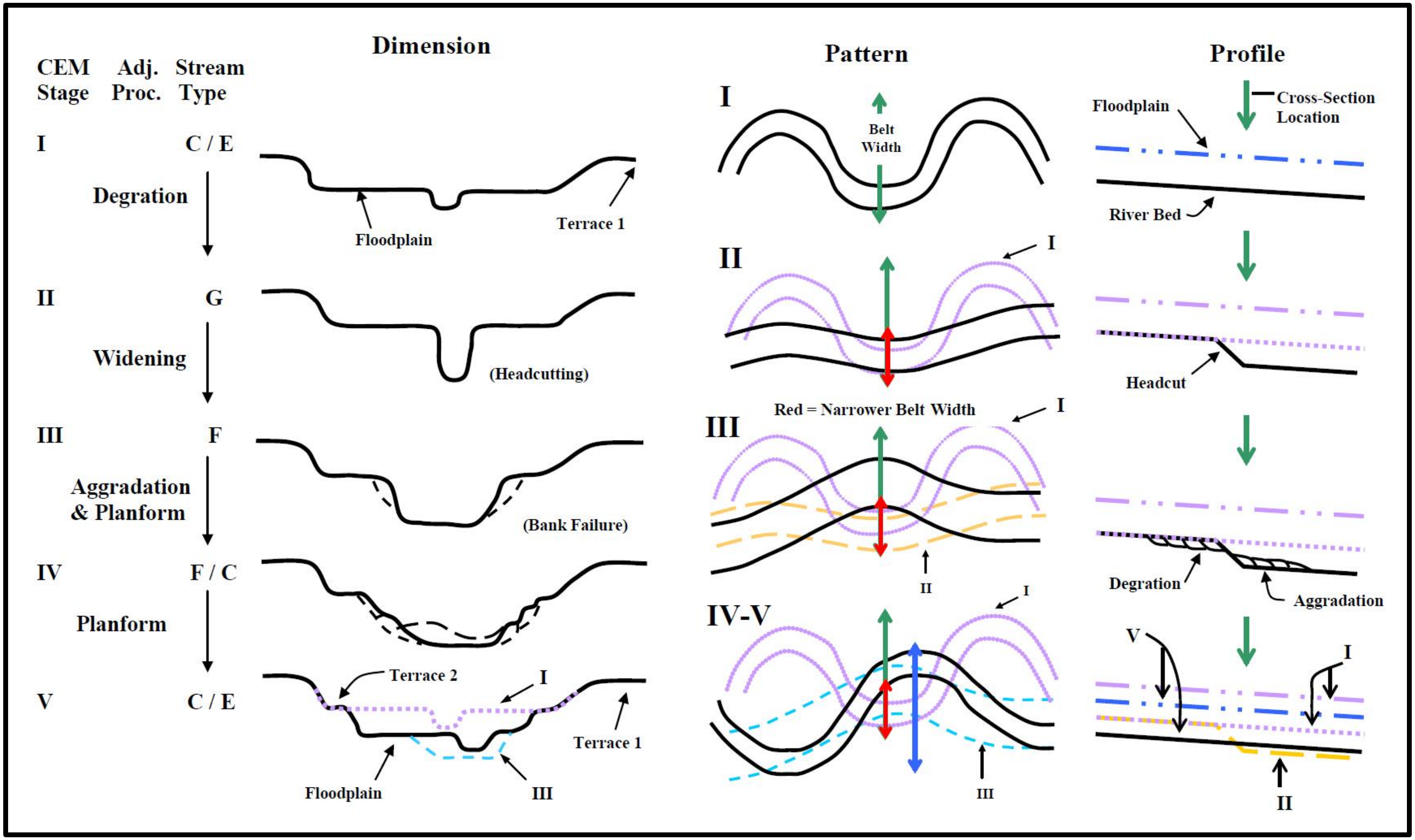



**Figure 24.** Channel evolution model (CEM) for incised channels (adapted from Schumm 1977, 1984 and Thorne et al. 1997 by Vermont Agency of Natural Resources 2007)

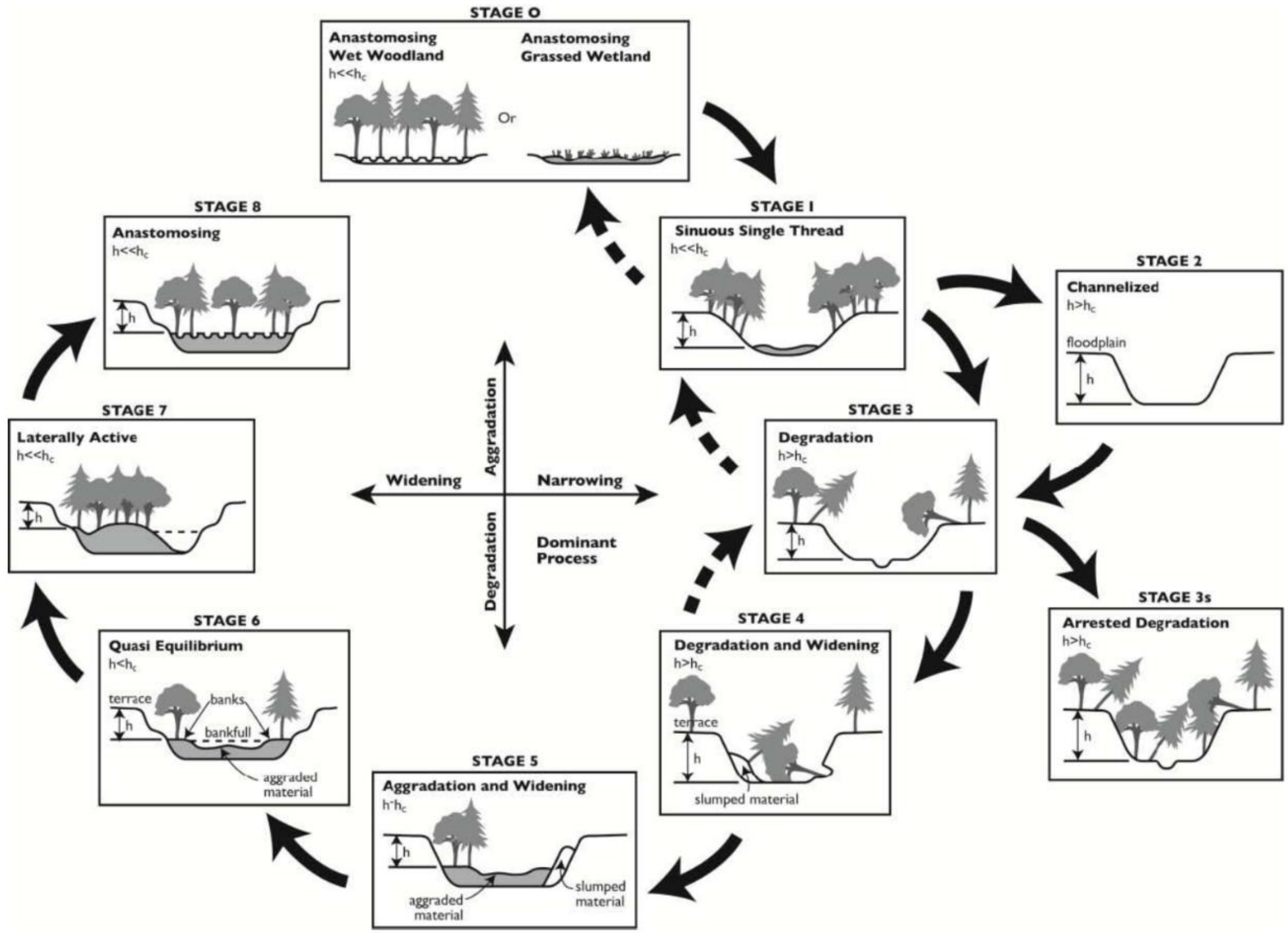



**Figure 25.** Stream evolution model for incised channels (Cluer and Thorne 2014).

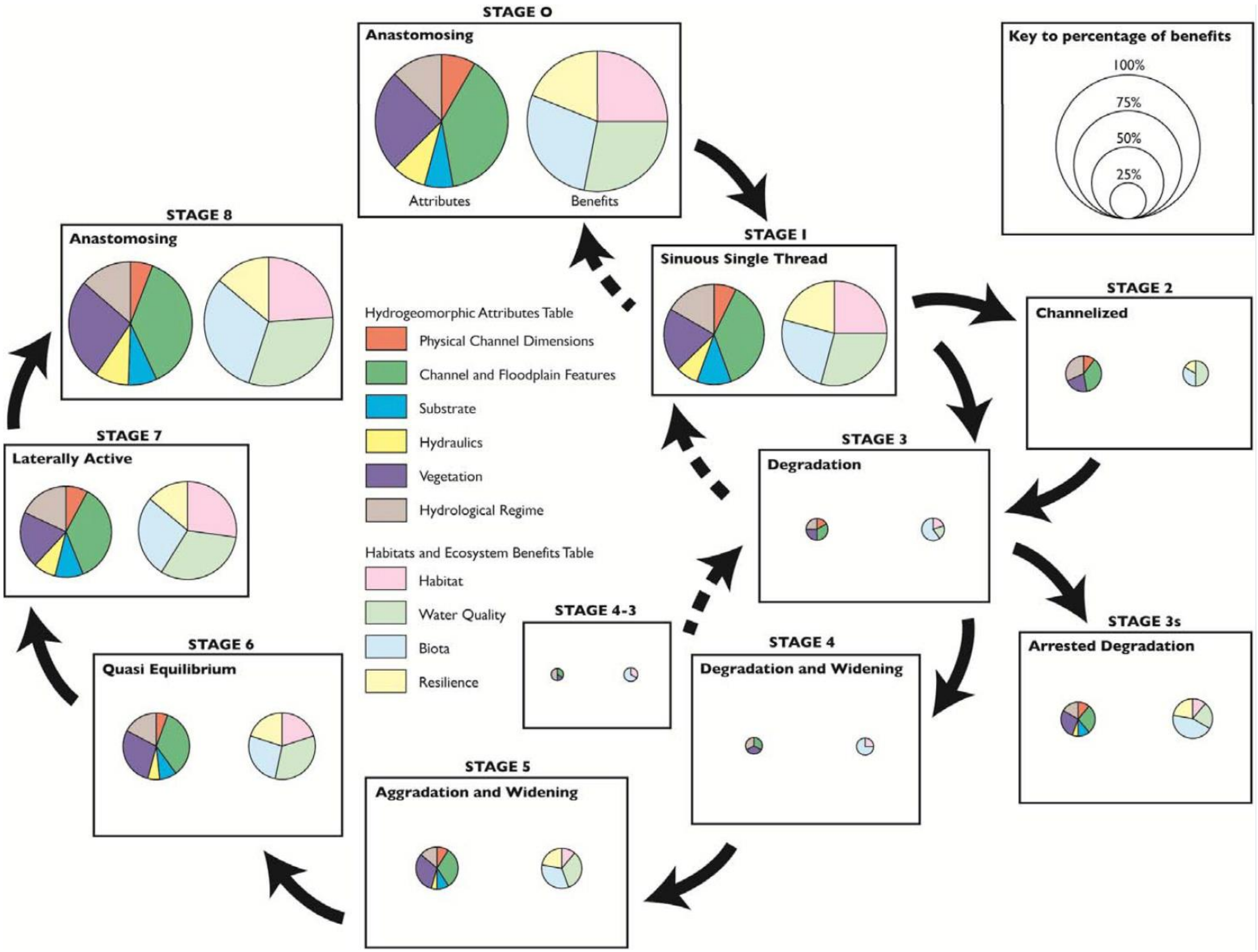



**Figure 26.** Habitat and ecosystem benefits for the stream evolution model of incised channels (Cluer and Thorne 2014).

channel is at 'stage zero,' where the channel is highly connected with its floodplain and forms an anastomosing, multi-threaded channel pattern.

While restoration of Mill Creek to its historical 'stage zero' status is not feasible in this urbanized environment, a much wider multi-threaded channel and floodplain area could be created to form a quasi-equilibrium status between sediment supply and sediment transport. Any long-term solution to maintaining fish passage between the natural stream reach and the flood control zone channel will have to provide for a long-term source of coarse sediment and a reduction in the stream power as it flows through the natural channel. Some combination of the following management actions should be considered to reduce the energy of Mill Creek during high flows and prevent continued channel incision:

1. Raise the channel bed closer to its historical elevation so that high flows spread out onto a wider floodplain area.
2. Widen the currently incised channel and create additional floodplain area.
3. Introduce large wood pieces and wood jams into the channel.
4. Increase riparian vegetation by raising the groundwater table and encouraging tree growth along the channel and adjacent floodplain.
5. Add additional cobble and gravel or other substrate mix to the channel bed.
6. Create a roughened channel with large enough base rock to resist channel incision.
7. Siphon high flows from the channel and release the water back to the stream when flows have receded.

## 6.0 References

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# APPENDIX A

# Historical Aerial Photographs


**Figure A-1.** Rectified 1939 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-2.** Rectified 1952 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-3.** Rectified 1957 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-4.** Rectified 1964 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-5.** Rectified 1976 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.

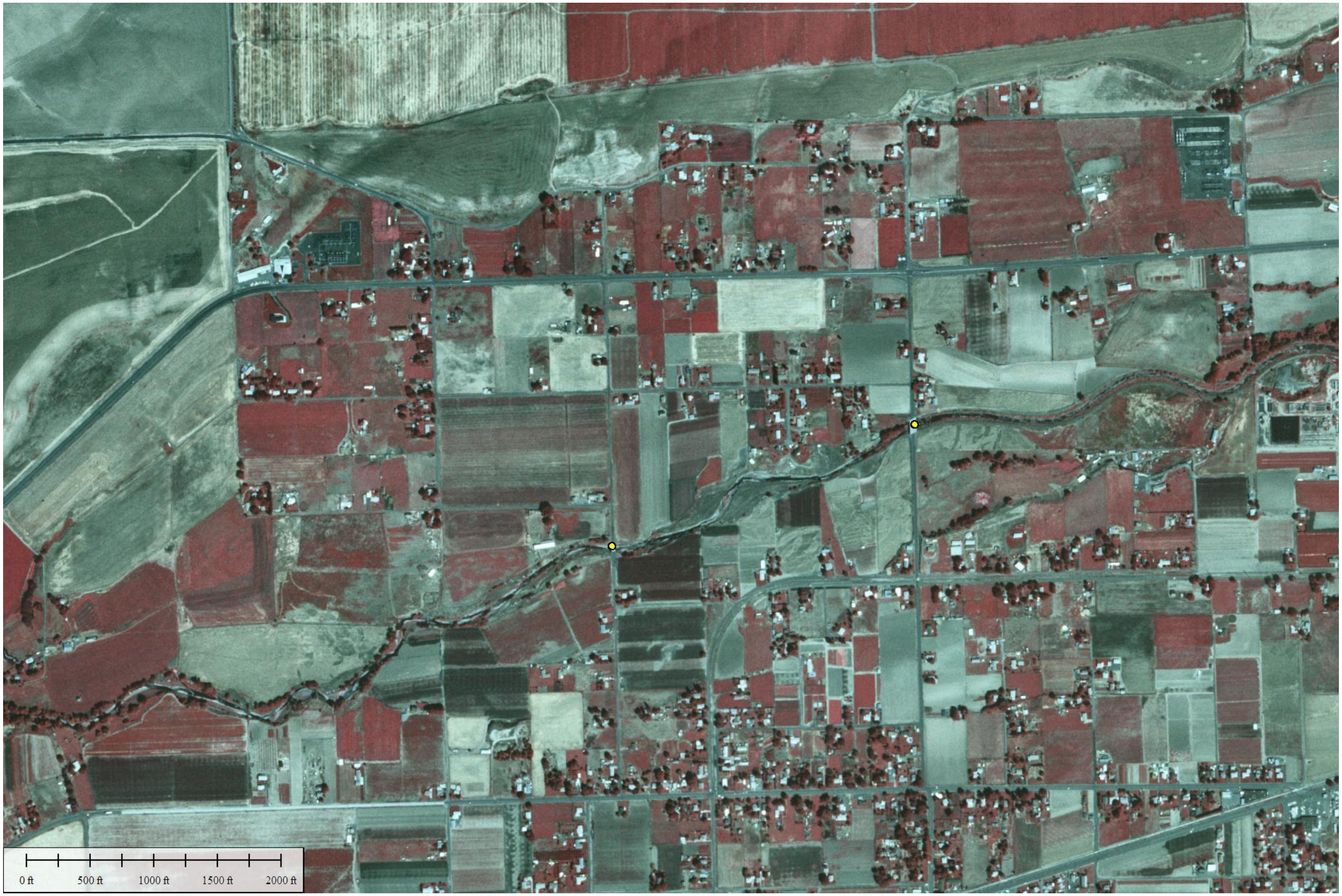



**Figure A-6.** Rectified 1982 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-7.** Rectified 1996 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-8.** Rectified 2006 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.

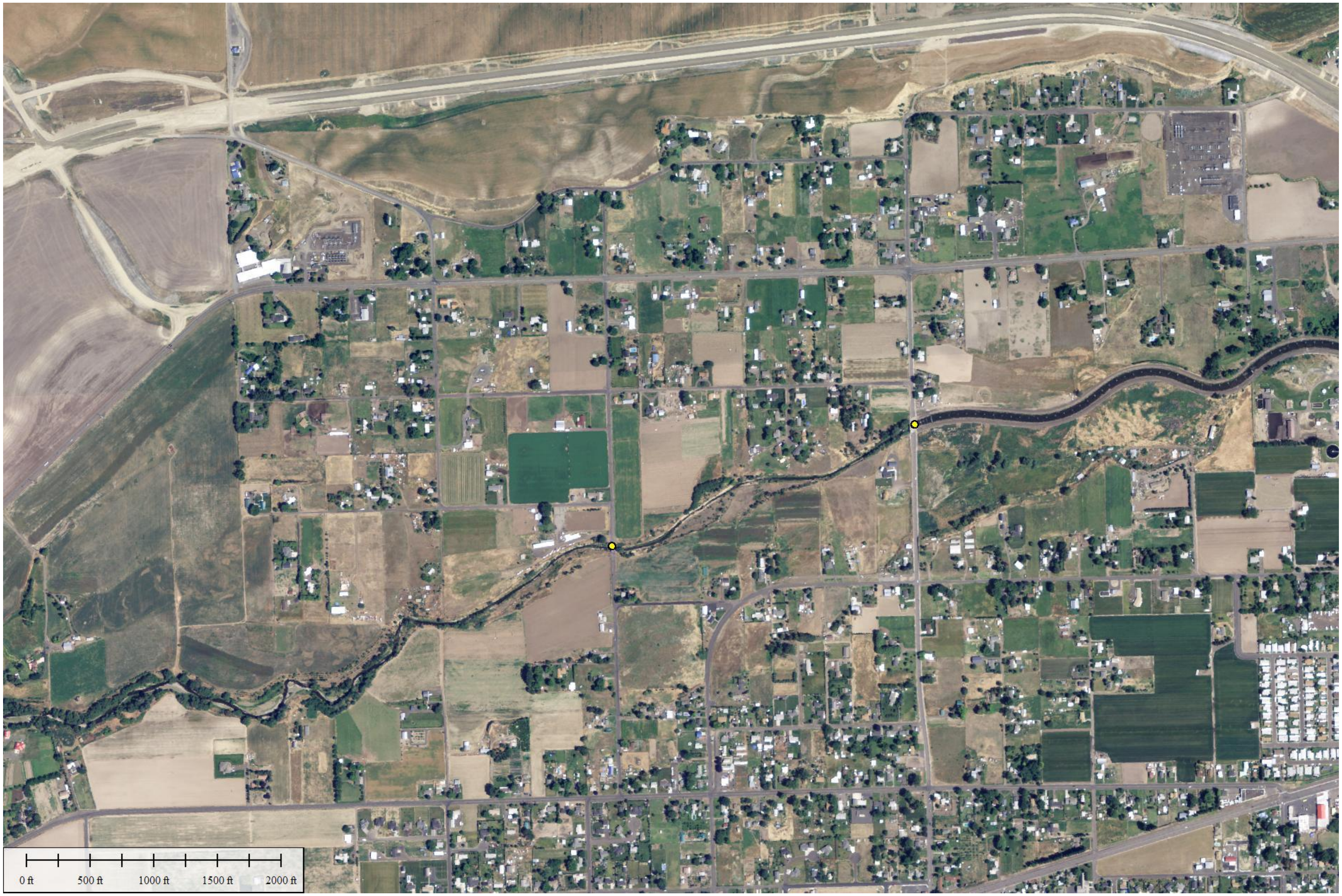



**Figure A-9.** Rectified 2009 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-10.** Rectified 2011 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.

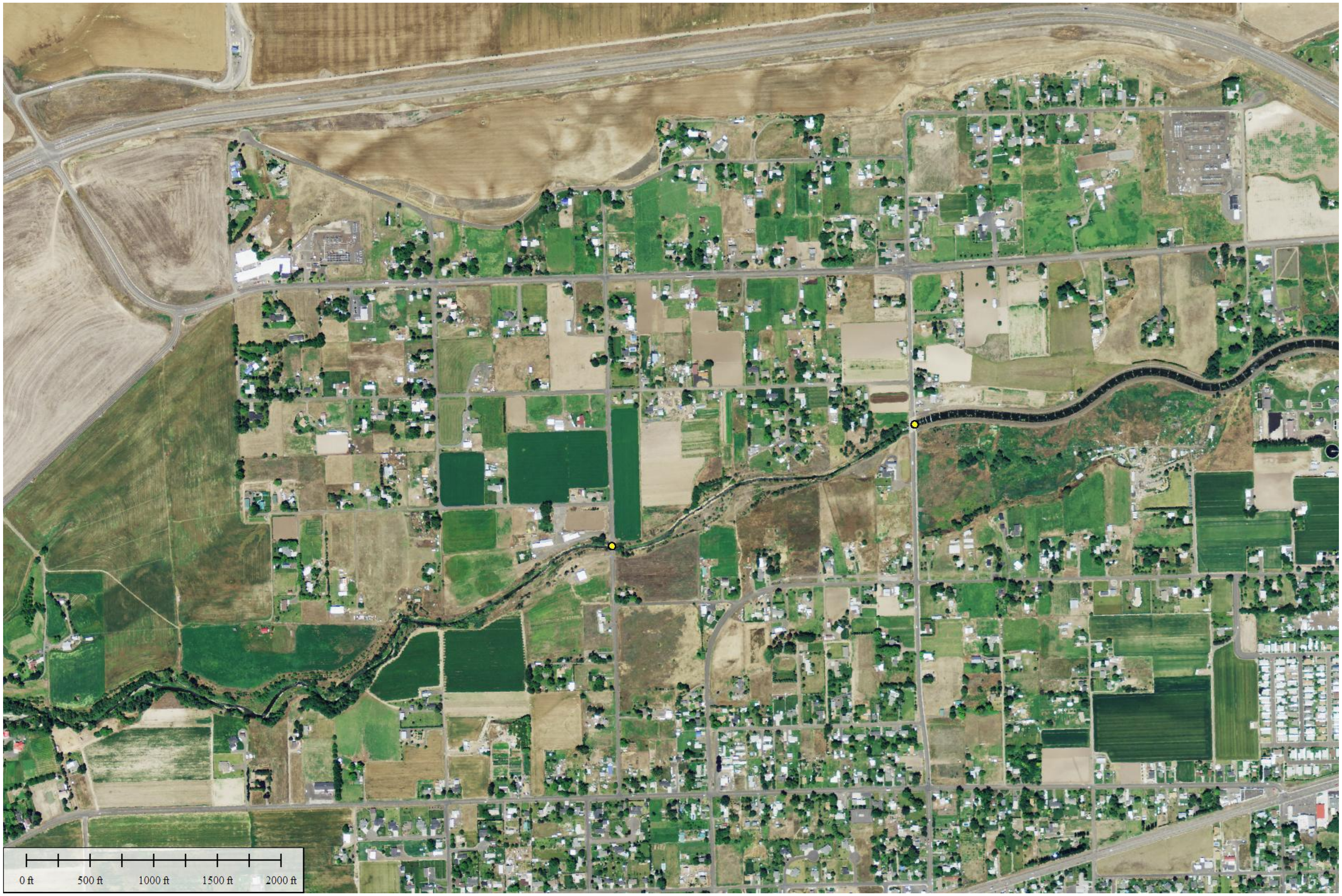



**Figure A-11.** Rectified 2013 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-12.** Rectified 2015 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-13.** Rectified 2017 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-14.** Rectified 2019 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.


**Figure A-15.** Rectified 2021 aerial photographs highlighting the Gose and Hussey Street crossings (yellow dots) of Mill Creek.

## 3 SURVEY AND PROJECT BASE MAP

The survey base map was developed from the 2018 Quantum Spatial LiDAR, the 2021 LiDAR (NV5, 2021) and a survey by PBS Engineering and Environmental Inc. (PBS). Cross sections from the PBS survey were used to modify the LiDAR contours from the 2021 data set. The horizontal datum of the survey was based on Washington State Plane coordinates south zone, NAD 83/2011 and the vertical datum was NAVD 88. Details of the project under the bridge and within the fishway were copied from the 2006 drawings from Anchor Environmental, LLC. Other details of the concrete and sheet pile weirs and bridge were taken from 1951 CORP drawings and 1969 Walla Walla County drawings of the bridge.

## 4 COUNTY BRIDGE AND STRUCTURAL CONCERNS

To be Added

## 5 HYDROLOGY

*(note: the hydrology portion of this report is not complete, but the design flows will likely not change from the ones being used since 2010).*

The fish passage design and flood flows used for all of the work on the Mill Creek Fish Passage Project were based on USGS gage data at Station 1401500. This station had daily flow data from 1941 to 2023 (82 years). In 2013, a statistical analysis of the data was done to determine the 10, 50 and 90 percent exceedance flows for the months of fish passage concern (Steelhead, Spring Chinook and Bull Trout). From this design flows of 10, 92, 194 and 320 cfs were used to design for fish passage.

A stream gage has been installed upstream of Gose Street with the intent of correlating frequent high flows and low flows to the STA 1401500 gage. This data will be correlated in the fall of 2023 and a statistical analysis of monthly flow exceedances will be done to further verify and check the design flows for fish passage.

Figure 2 is a plot of Mill Creek floods since 1941. The two large events are the 1996 and the 2021 floods. Based on this data, the following design flood flows will be used:

2-year: 980 cfs

10-year: 2200 cfs

100-year: 4000 cfs

The design criteria for the Mill Creek Flood Control Project are to start diverting water into Bennington Lake at flows of 1400 cfs and trying to control releases down into the City of Walla Walla to 3500 cfs. Further analysis is proposed using the WDFW Climate Change model to look at future flows and project life.

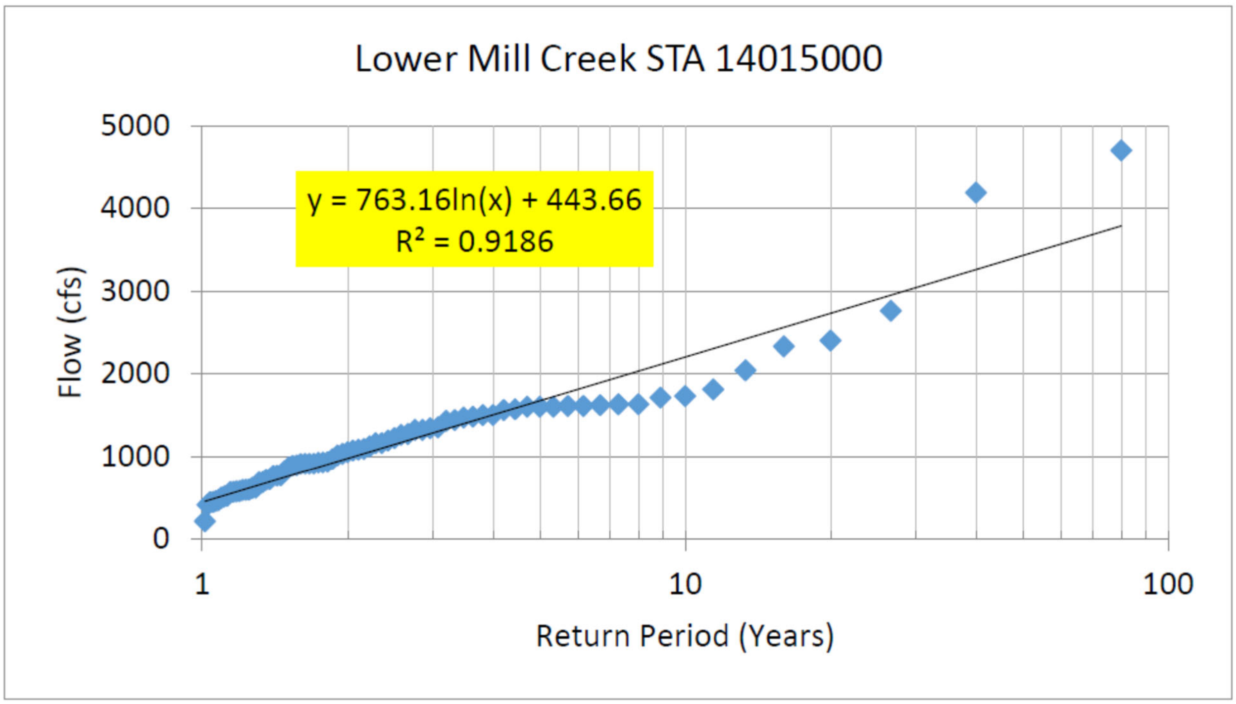



**Figure 2 – Plot of Mill Creek floods from 1941 to 2023.**

## 6 FEMA FLOOD ZONES

The FEMA flood study for Walla Walla County was done in 1984. Figure 3 shows the zones related to the Gose Street area of Mill Creek. Two zones are designated, A4 and B. A4 is a high-risk flood area and B is a moderate flood hazard area. For the two cross sections shown in Figure 4 (Z and Y), the 100-year flood elevation was 799 and 783 respectively. The current HEC RAS 1D model has the 100-year flood at these same locations of 793 and 783 (6 and 5 feet lower). This is consistent with the channel incision assessment from the Geomorphic Assessment in Chapter 2.

With Option 2 as the selected design the channel will be raised to elevation 788.6 at Section Z on the FEMA Profile. This will raise the bed 6 feet from existing, and the channel toe width will be increased to 50 feet (the existing is 24 feet). The design will seek to maintain existing flood levels by widening the channel and sloping the banks.

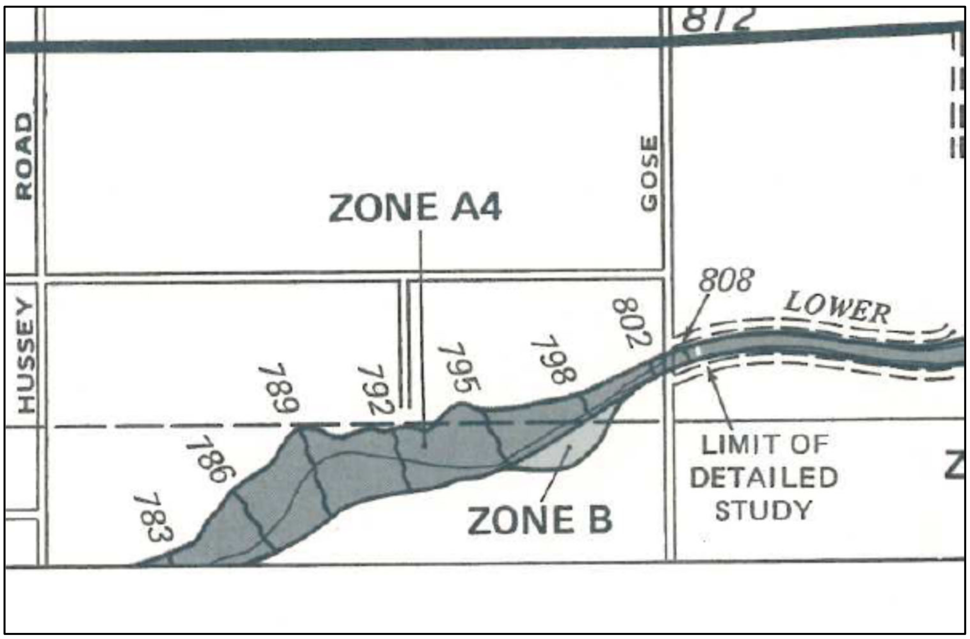



**Figure 3 – FEMA Flood Zones.**

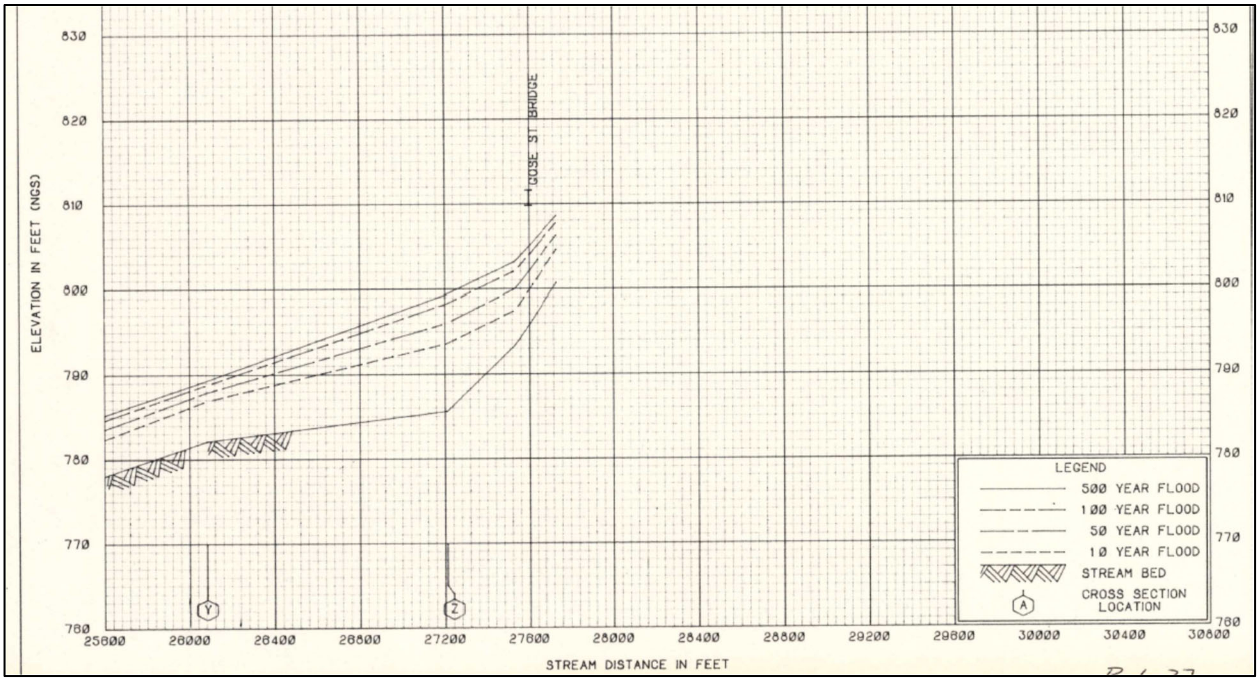



**Figure 4 – FEMA Flood Water Surface Profiles.**

# 7 HYDRAULIC MODELING RESULTS

A 2D HEC RAS model of the existing conditions was developed and a 1D model of the proposed Option 2 was developed, see Appendix B1 and B2. For the selected Option 2, a more detailed 1D model will be developed with the proposed fishway changes added and details of the channel meandering and pool/riffle profile.

*Note: This modeling is the next key piece for the design and will be completed by fall of 2023. Enough modeling has been done to date to verify the conceptual design. The additional modeling will add channel complexities such as pool/riffle sequence, a meandering thalweg, bench cuts in the bank and a more detailed assessment of the sediment sizing. At this point a 1D model will best represent the conditions of flow transition from the bridge with piers to vertical walls in the fishway.*

# 8 DESIGN ALTERNATIVES

Designs developed need to address the problem of channel incision at the downstream end of the flood control channel. The end of the flood control channel is a concrete sill at elevation 800. The streambed downstream of the fishway is now at 783. So, the bed has down cut 17 feet since the flood control channel was built in the 1940s, and predictions are in the next 30 to 50 years there could be another 4 to 5 feet of incision.

The initial list of design options was presented to the Mill Creek Work Group (MCWG) on September 6, 2022. The options included additional fishways and weirs downstream to raise the channel and backwater the existing fishway, regrade the channel upstream of Gose Street to eliminate the fishways and create a new flood control channel outlet and a trap and haul facility. The discussion of these led to a direction to pursue raising and widening the channel downstream with either fishways, weirs or bypass channels. The trap and haul facility option was discussed but the issue of who would operate, where the facility would go on private land and the concern of potentially blocking fish during times when the facility is not functioning led to not considering this option further. The channel regrade upstream had some potentially difficult design issues to address, like undermining the existing bridge footings, and widening the channel onto private property where currently a house is present. This option was also not pursued further.

The final list of design options is shown in Figure 5. There are 16 landowners within the project reach and each design option had a potential impact on private land. Five meetings were held with the landowners with varying success. Based on feedback from the landowners these options were modified to five final options. In addition to the design options, a gravel augmentation phase was proposed and discussed. The idea comes from the fact that the gravel supply downstream of Gose Street is limited by the dams and flood control channel upstream. Gravel is excavated out of Mill Creek upstream near the City intake, at Bennington Dam, and in the wide channel concrete sills area. If there was a place downstream of Gose Street to place the gravel in the floodplain the material could wash into Mill Creek naturally over time. This would benefit the channel construction and provide habitat for the downstream reaches of Lower Mill Creek.

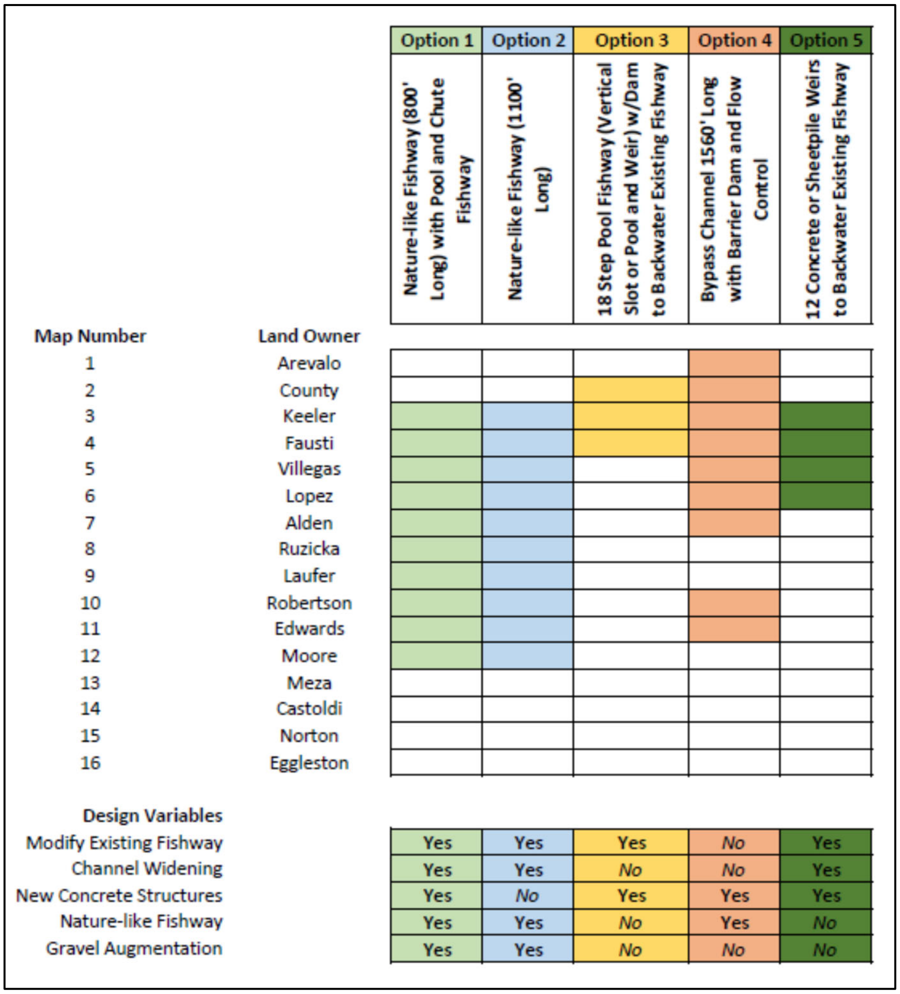



**Figure 5 – Design options and relation to landowner parcels with design variables.**

Each option had specific design variables which have a major impact on the overall project. These included modifying the existing fishway, widening the channel, placing new concrete structures, using nature-like fishway designs and how gravel augmentation would play a role. The following is a description of each design. Drawings of each are provided in Appendix E1.

Option 0: Do Nothing

This option was included as a baseline for scoring. Some work has been done by WDFW to backwater the fishway by placing concrete blocks in the channel to form weirs. Some of these blocks have moved but the basic structure is in place and provides some level of passage.

Option 1: Nature-like Fishway (800′ Long) with Pool and Chute Fishway

This option includes a new Pool and Chute fishway located 84 feet downstream of the existing fishway and then 800 feet of new constructed "nature-like "channel downstream. The downstream end of the new channel would allow for 3 to 4 feet of channel incision.

The new fishway width would be 26 feet with 13-foot-long pools. The floodplain of the channel would be widened to 50 feet (currently the channel is 25 feet wide), with 2:1 side slopes on the left bank. Wing walls and rock riprap would be used to backfill to the top of the walls. The drop at each weir would be 0.8 feet, so the overall slope of the fishway would be 6.2 percent. This would leave a 3-foot drop at the downstream end of the fishway which would be the starting point for the channel downstream. The fishway width, drop, length and slope were optimized based on monitoring results by the author of the existing Pool and Chute Fishway and others built in Washington and California. Then, starting at a distance of 60 feet downstream of this new fishway an 800-foot-long Nature-like Fishway would be constructed. The slope of the channel would be 1.4 percent. The channel would be widened to 50 feet.

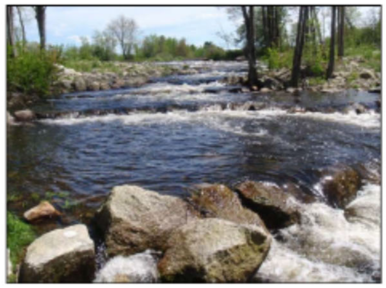
Cut-off walls to seal the bed would be on average three feet high and countersunk one foot into the channel bed to create a low water seal. The length of the cut-off walls would vary from 20 to 30 feet. The constructed riffles would be spaced 55 feet with a drop of 0.8 feet for an average slope of 1.4 percent. Depending on modeling results the drop or riffle would include a cut-off wall which would be either 1) a concrete weir, 2) a concrete box filled with boulders to form a riffle (rocks in a box), or 3) boulder weirs to form a roughened channel (Figure 6). Most likely the design would have either a concrete or sheet pile weir buried underneath boulders and cobble ranging in size from 4 feet to 6 inches. After the cut-off walls are placed the channel would be filled with existing material excavated from the bank. The top 3 to 4 feet would be an imported roughened channel mix to form the channel.

**Figure 6 – Example photos showing (from left to right), showing Nature-like Fishways a boulder riffle and roughened channel and a series of boulder drops.**

In addition to the new structures, the existing pool and chute fishway (20 feet wide by 10-foot-long pools) will be modified to improve the hydraulic performance based on past monitoring observations. The following design modifications are proposed.

1. Increase the fishway width by 6 feet on the left side.
2. Slope back the vertical left bank at 2:1.
3. Anchor steel plates in areas where concrete erosion has occurred.
4. Seal existing voids in the fishway foundation and concrete spillway on the right bank by pressure grouting.
5. Widen the channel on the left bank to provide an area for fish to rest in the plunge pool before passing.

Saw Mill Park step-pool fishway,
Acushnet River, Acushnet, MA



Fields Pond step-pool fishway,
Sedgeunkedunk Stream, Orrington, ME

Kenyon Mill step-pool fishway,
Pawcatuck River, Richmond, RI

Homestead dam removal and NLF cross-vanes,
Ashuelot River, West Swanzey, NH

Water Street tidal rock ramp,
Town Brook, Plymouth, MA

Lower Shannock Falls NLF weirs,
Pawcatuck River, Richmond, RI

**Figure 7 – More examples of Nature-like Fishways from Federal Interagency Nature-like Fishway Design Guidelines, 2016.**

Option 2:  Nature-like Fishway (1100 feet long) to Backwater Existing Fishway

This option is similar to Option 1 in design, but the overall slope is steeper by 22% (1.8 percent and the drop structure spacing is 45 feet.  Some of the drop structures at the upstream end will be 6 to 7 feet high above the streambed, compared to 2 to 3 feet high for Option 1 and these may require a concrete weir design.  The difference between Option 1 and 2 is mainly due to the concern over the steep energy grade line and stream power coming from the slope of the existing fishway and bridge constriction.  It may be difficult to design a long-lasting "nature-like fishway" in this area, and the cut-off wall height for the upper 5 to 6 structures may be very costly due to the height.

Option 3: Pool and Weir Fish Ladder with Dam

This Option would consist of building a 10 to 12-foot-high dam or weir across the channel at the downstream end of the existing fishway, which would backwater up to the pool under the bridge.  The fishway would have 20 steps.  The fishway type would be either a pool and weir or vertical slot.  See Figure 8.  The downstream end of the fishway would extend 3 to 4 feet below the existing bed to account for future channel incision and there would be a concrete stilling basin to dissipate the energy from the spill.  This option would abandon the lower existing fishway under the bridge.  Fish would exit the fishway into a deep-water pocket under the existing bridge.

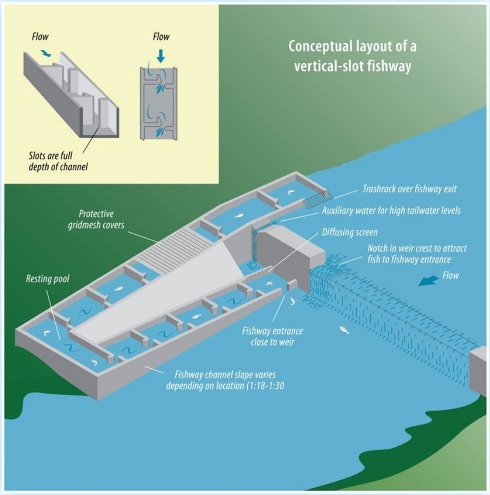




**Figure 8 – Examples of Pool and Chute, Pool and Weir and Vertical Slot Fishways.**

<u>Option 4: Bypass Channel with Barrier Dam and Flow Control</u>

Option 4 is a 1560-foot-long bypass channel with a slope varying from 0.5 to 4 percent. The flow in the channel would vary from 10 to 100 cfs. The channel width would average 20 feet. Construction of a velocity barrier dam 1300 feet downstream of S. Gose Street would be required to force fish into the channel (Figure 10). Initially this dam is proposed as a velocity barrier dam to reduce the amount of backwatering and depth upstream. At the upstream end of the channel, it would cross under S. Gose Street in a 10-to-12-foot diameter culvert and then into a flow control section with either a slotted fishway or an automated closure gate to reduce the potential for flood flows entering the channel. The bypass channel would be a natural channel (not fishway) constructed of appropriately sized streambed cobbles and boulders with a riparian corridor. The channel would be set back 20 feet from the top of the bank. At the downstream end the channel would be constructed 3 to 4 feet below the existing bed to account for future channel incision.


**Figure 9 - Example of bypass channel around an existing dam.**

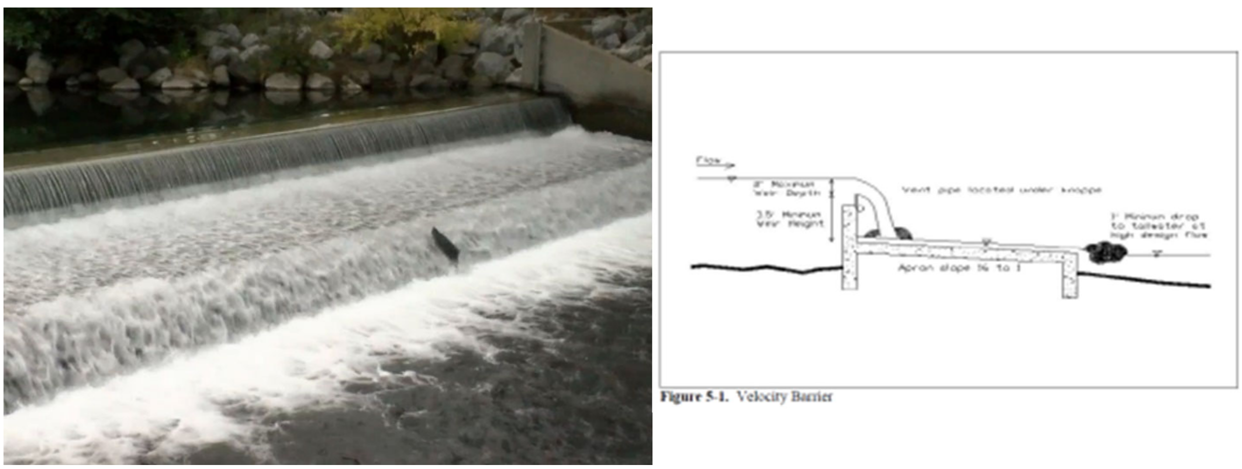


Figure 5-1. Velocity Barrier

**Figure 10 – Velocity barrier example. Sketch to the right is a profile view.**

Option 5: Concrete Weirs

Option 5 would be a series of 20 concrete weirs spanning the channel with 1-foot drops. The weir spacing would be 40 feet and the overall channel slope 2.5 percent. The weirs would have a low flow notch and look very similar to the weirs upstream of S. Gose Street in the flood control channel. The weir length would be 40 to 50 feet. The weirs would be shaped to concentrate flow more in the center of the channel. This Option requires the existing fishway under the bridge to be modified as described in Option 1. Two design options are shown in Figure 11.


**Figure 11 – Concrete weirs spanning channel constructed in 2005 (left) and Goldsborough Creek Concrete Weirs (right) during construction.**

## 9 ALTERNATIVES SCORING

The process used to select the preferred alternative was to rank each option relative to attributes which were critical for the project to be successful and meet the overall project objective. An example of the scoring format is provided in Appendix F. Seven people were selected or volunteered to score the projects. All were members of the MCWG Technical Committee from various agencies with skill sets in fish passage design, fisheries biology and hydraulics. A meeting was held with participants to further explain the process and answer questions. General guidance for scoring was:

1. Start with one attribute (for example: Landowner Concerns): Which option would have the highest score? Based on what we have heard Options 1 and 2 seem to be preferred, and mainly Option 2 because there is no fish ladder, so give Option 2 a score of 8 or 9.

2. Which Option would have the lowest score? Again, based on feedback Option 4 seems to be the least preferred, so give it a 3. Then fill in the rest between those values of 8 and 3.

Figure 12 provides a summary of the scoring for each option. Option 2 had the highest score followed by Option 1 and then Option 5. Figure 13 provides information on how each individual person scored the options.

The nature-like fishway design was preferred by most all MCWG members and landowners with a few exceptions. One landowner wanted the disturbance to stay closer to Gose Street and not extend downstream. But most landowners like the idea of more natural stream in their backyard as opposed to concrete. To achieve this, the channel needs to be widened to reduce the energy.

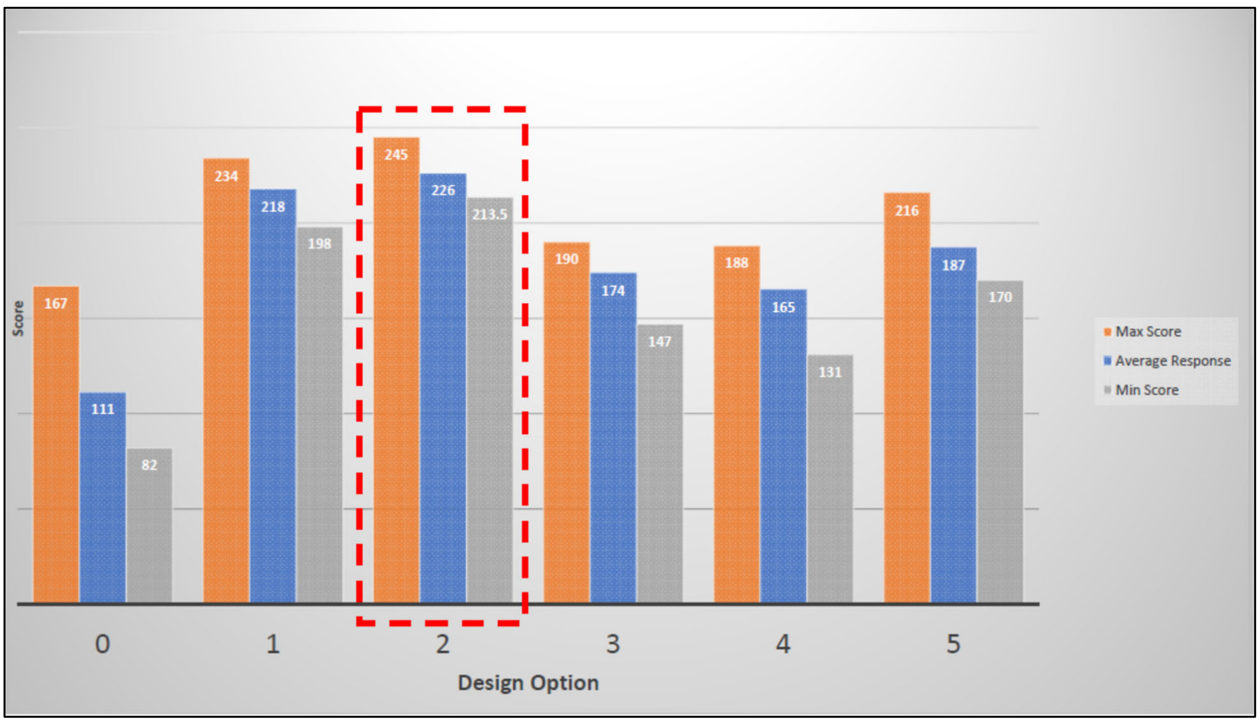



**Figure 12 – Average, maximum and minimum score for the five design options.**

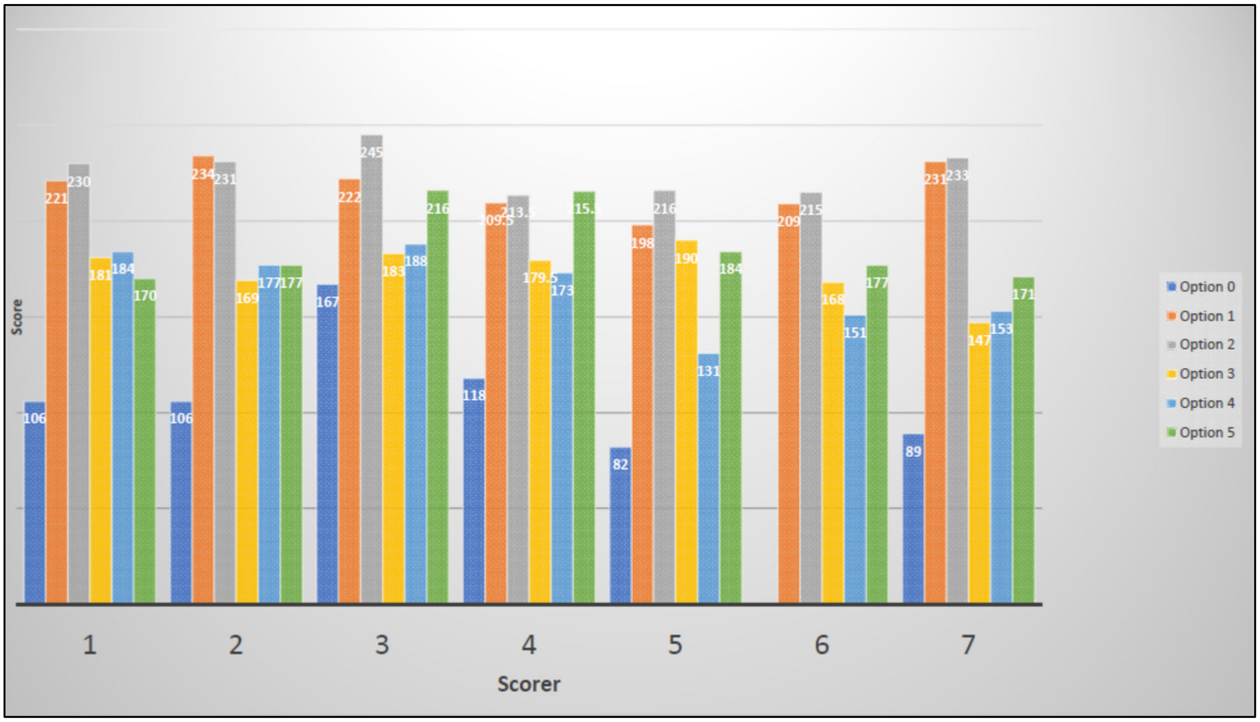



**Figure 13 – Individual scores from each participant for the five design options.**

## 10 OPTION 2 DESIGN

After Option 2 was selected as the preferred design, additional detail was added in an effort to address landowner concerns and other site details. Pacific Power has three large transmission lines on the left bank of the property (see Photo 7). Bank erosion has threatened one pole and riprap has been dumped/placed to prevent further erosion. Options to move the channel widening more to the right bank are being explored with landowners which may eliminate the need to move the poles. The cost of relocating the lines is also being pursued with Pacific Power.

Other details which have been added to the design include a meandering channel thalweg to create more channel complexity and roughness, a pool/riffle profile, widening of the channel at the fishway and cross sections at each landowner property showing benches for riparian planting. The channel widening will generate a surplus of gravel material (see Photo 8), which will be used to fill voids in the new channel rock and used to create piles of material which will wash downstream over time. These design details are shown in Appendix E2.

## 11 REFERENCES

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## APPENDIX A – SITE PHOTOS

**Photo 1 – View upstream of the lower fishway at 14 cfs (8/2/2022).**

**Photo 2 – View downstream of fishway at 14 cfs (8/2/2022).**


**Photo 3 – Mill Creek channel downstream of Gose Street (STA 21+00).**


**Photo 4 – Mill Creek STA 14+00 view downstream. Stationing starts (0+00) at Hussey Road.**

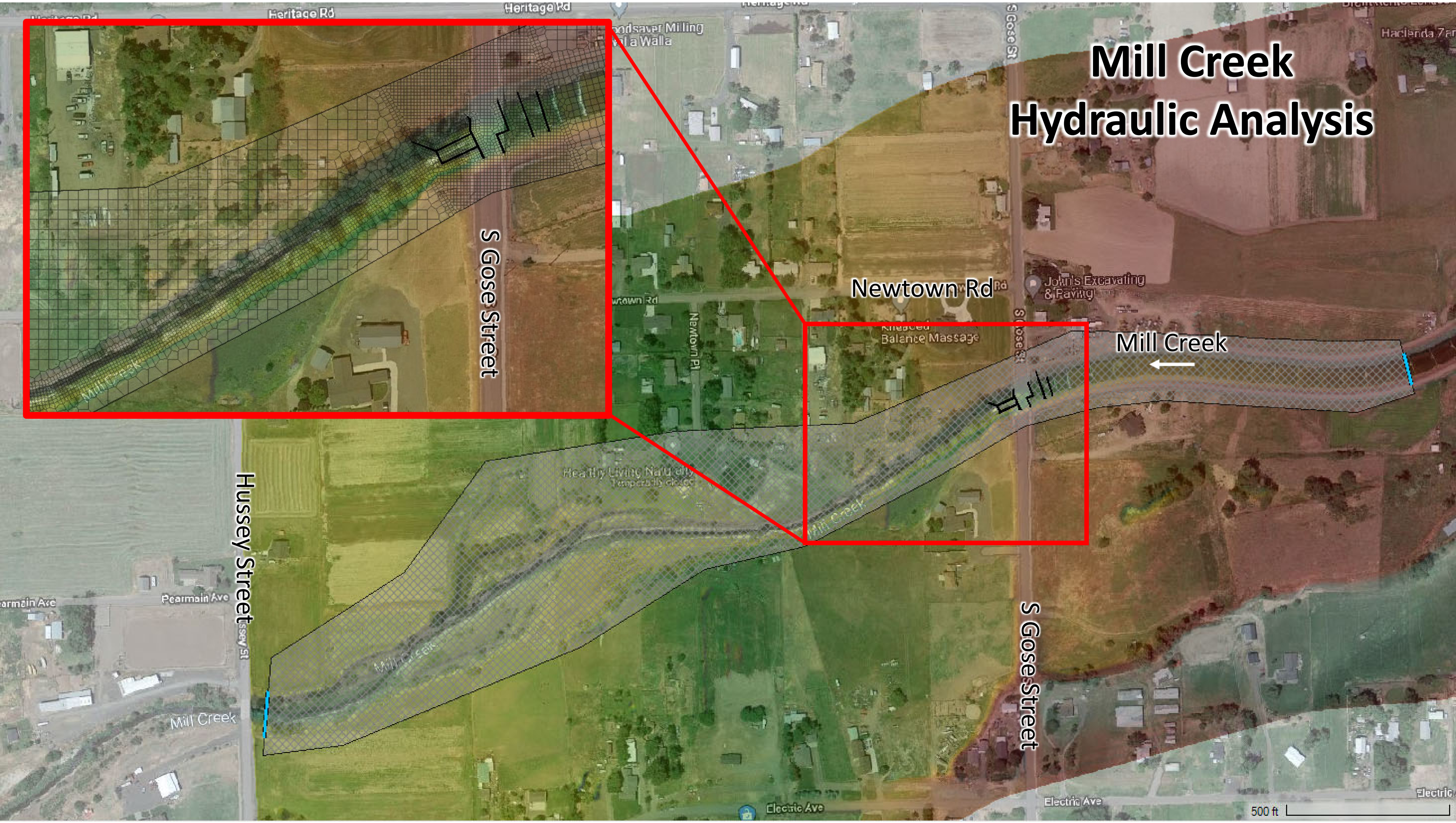

**Photo 5 – Drone photo from May 11, 2022 (flow 400 cfs).**

**Photo 6 – View upstream of fishway at 400 cfs. Note: the Upper design flow for the Mill Creek Fish Passage Project is 320 cfs (Adult Steelhead).**

**Photo 7 – Pacific Power transmission line on left bank of Mill Creek.**

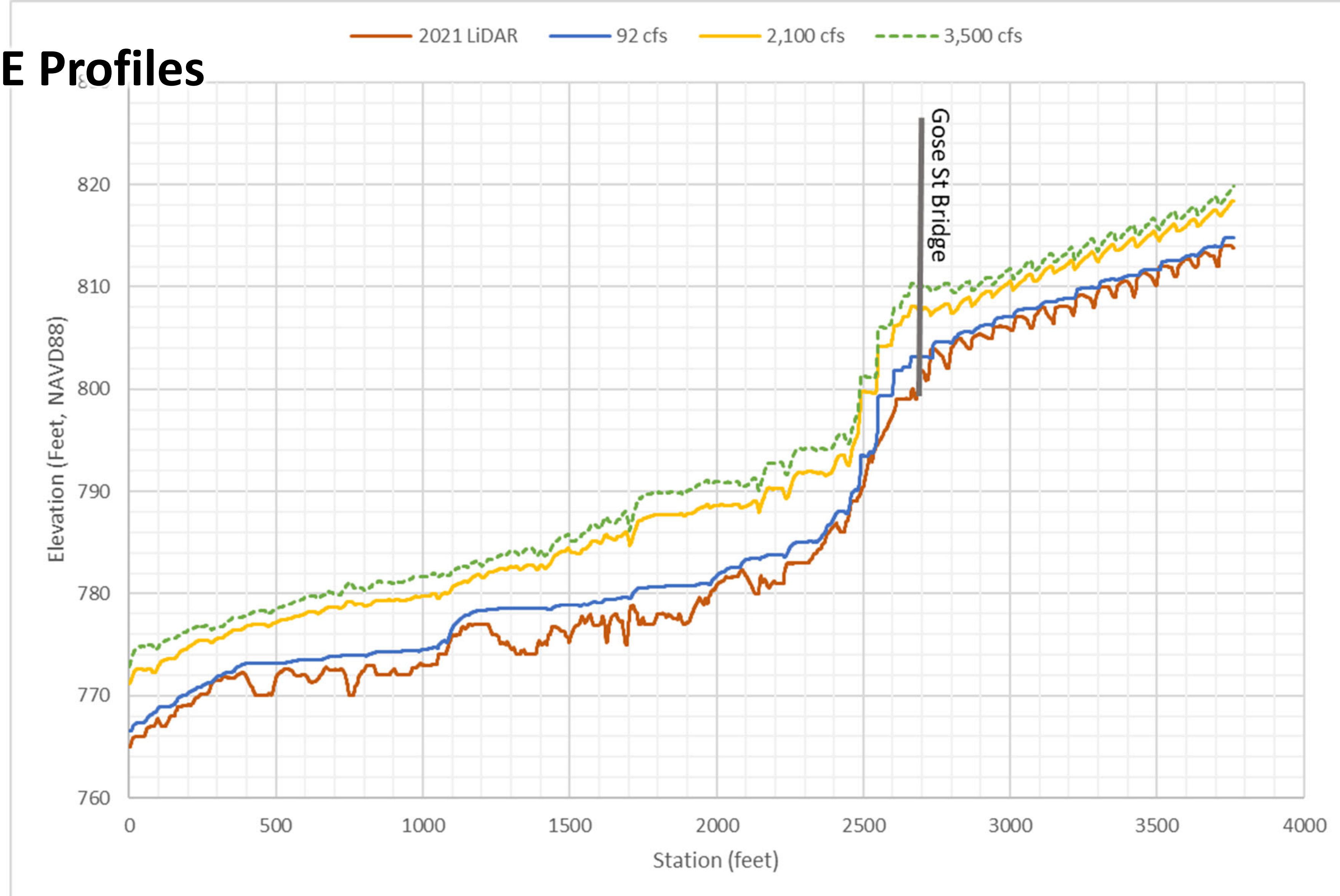

**Photo 8 - Typical bank material along Mill Creek downstream of Gose Street.**

# APPENDIX B1 – INITIAL 2D HEC RAS MODEL RESULTS

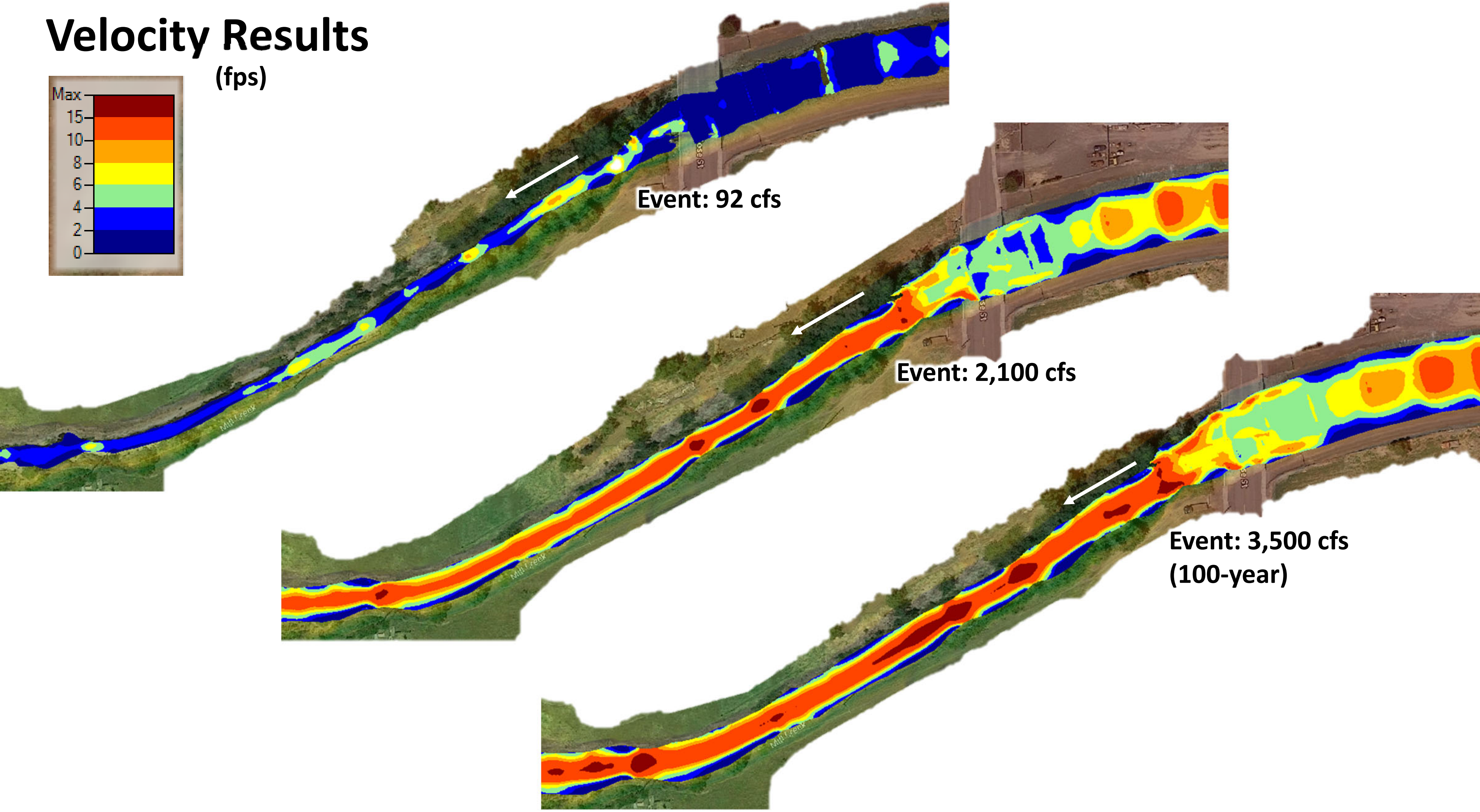


Mill Creek
Hydraulic Analysis
Heritage Rd
Newtown Rd
Mill Creek
S Gose Street
Hussey Street
Electric Ave
Pearmain Ave
500 ft

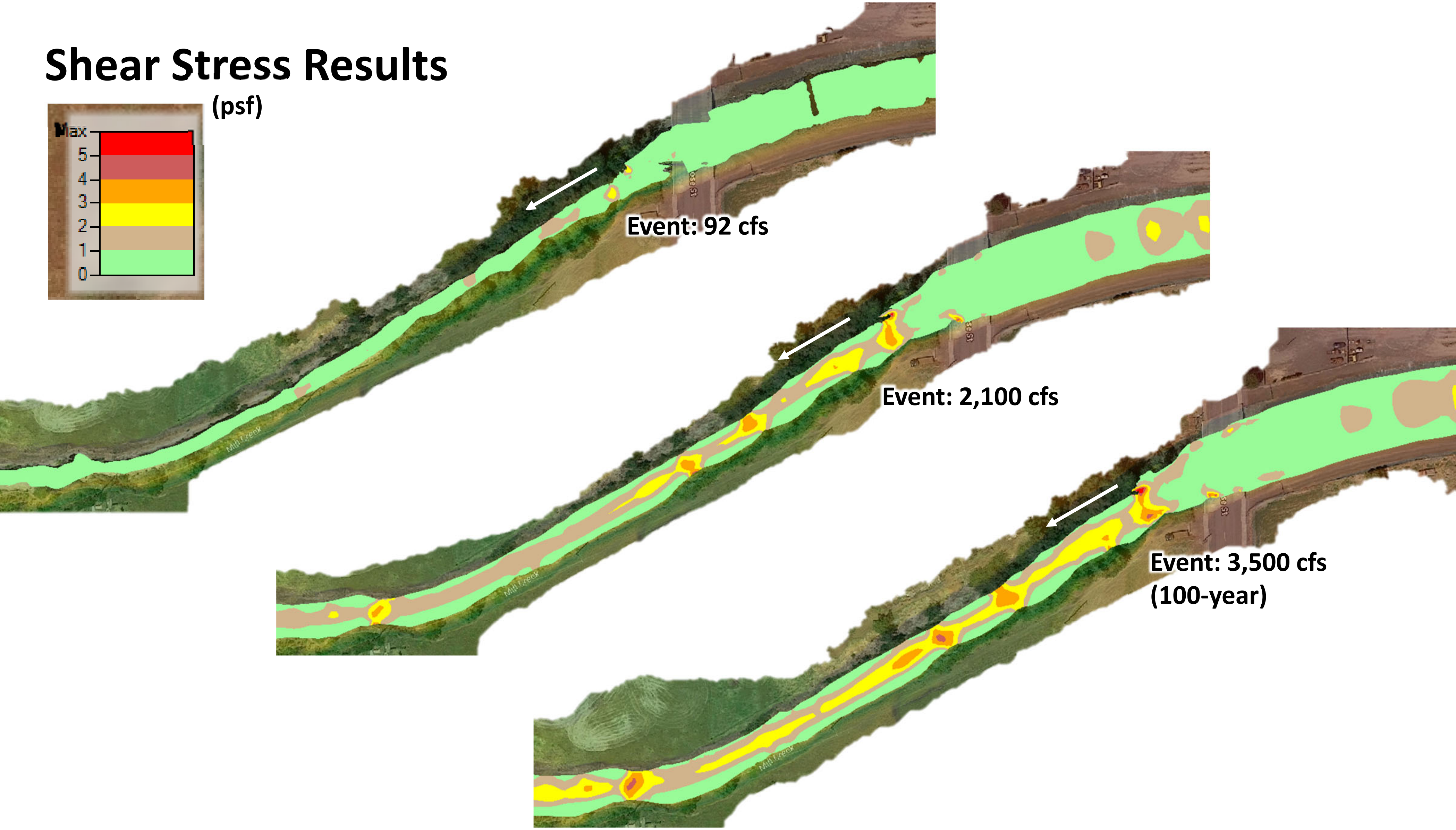
# WSE Profiles



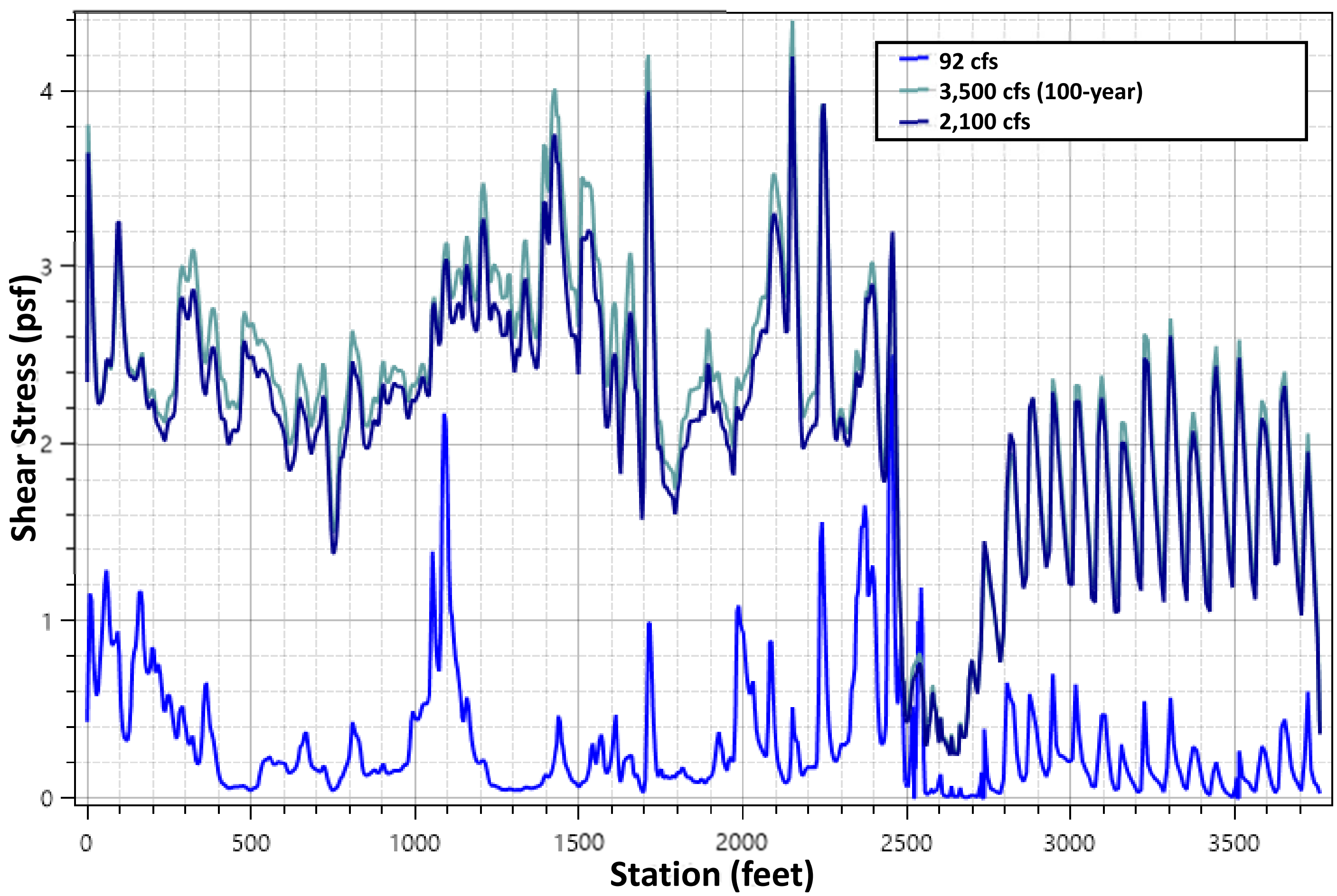
# Velocity Results



# Shear Stress Results



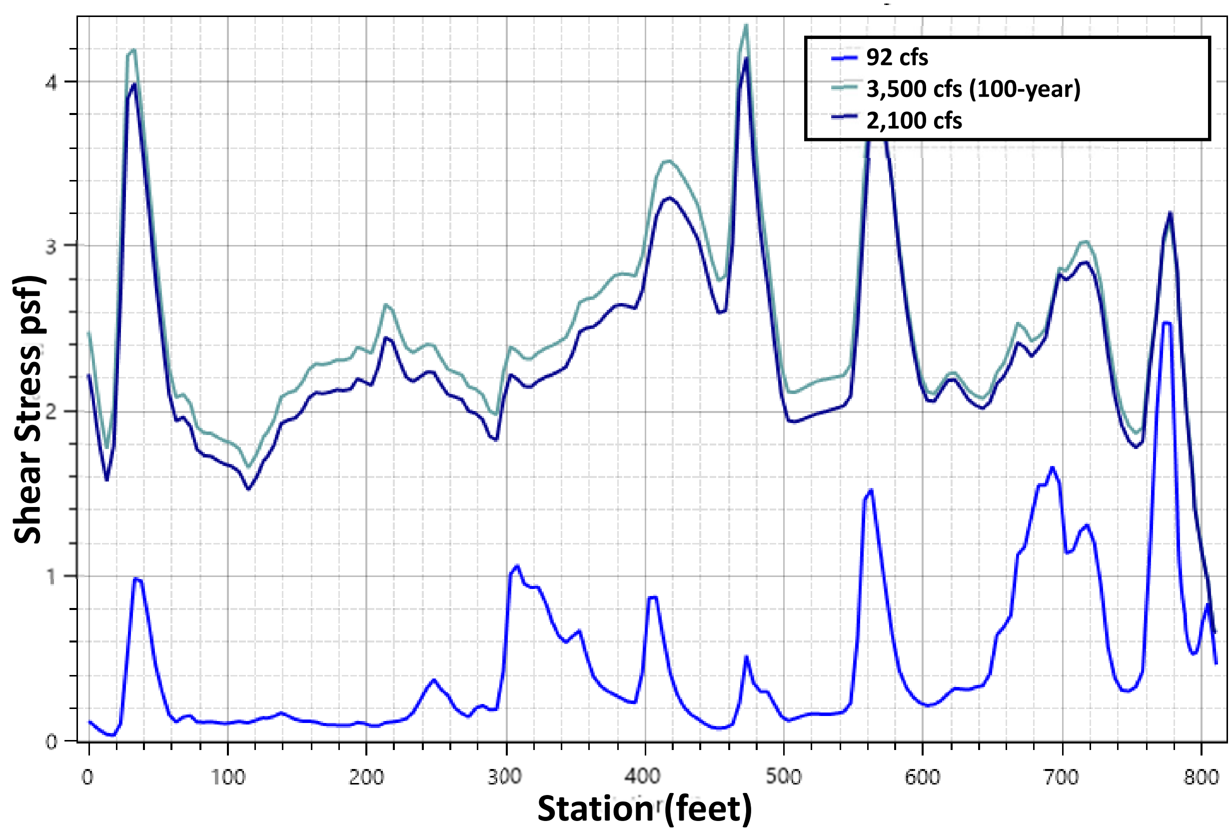
# Shear Stress Results (Full Domain)



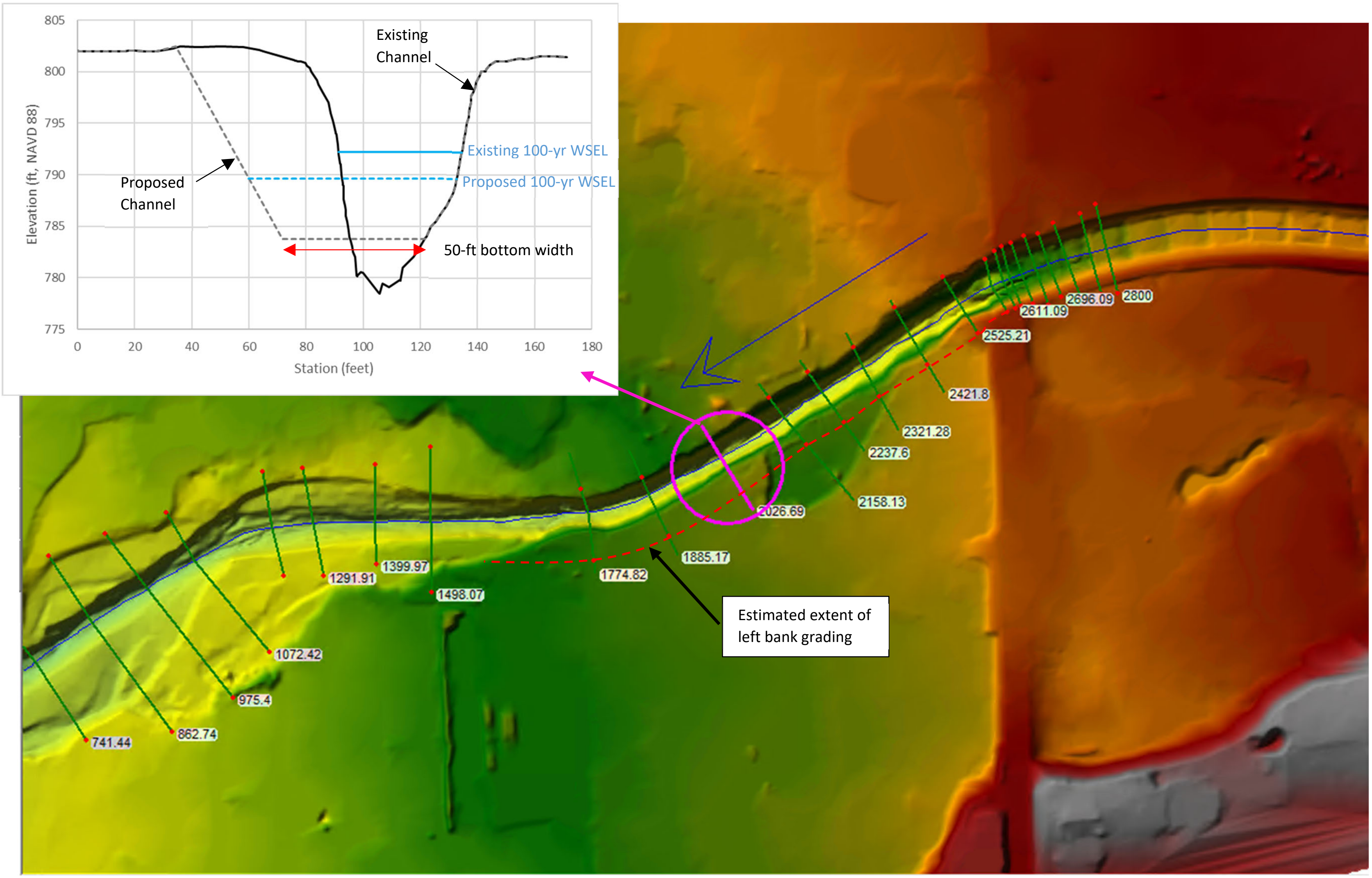
# Shear Stress Results (800 feet DS Gose Street)

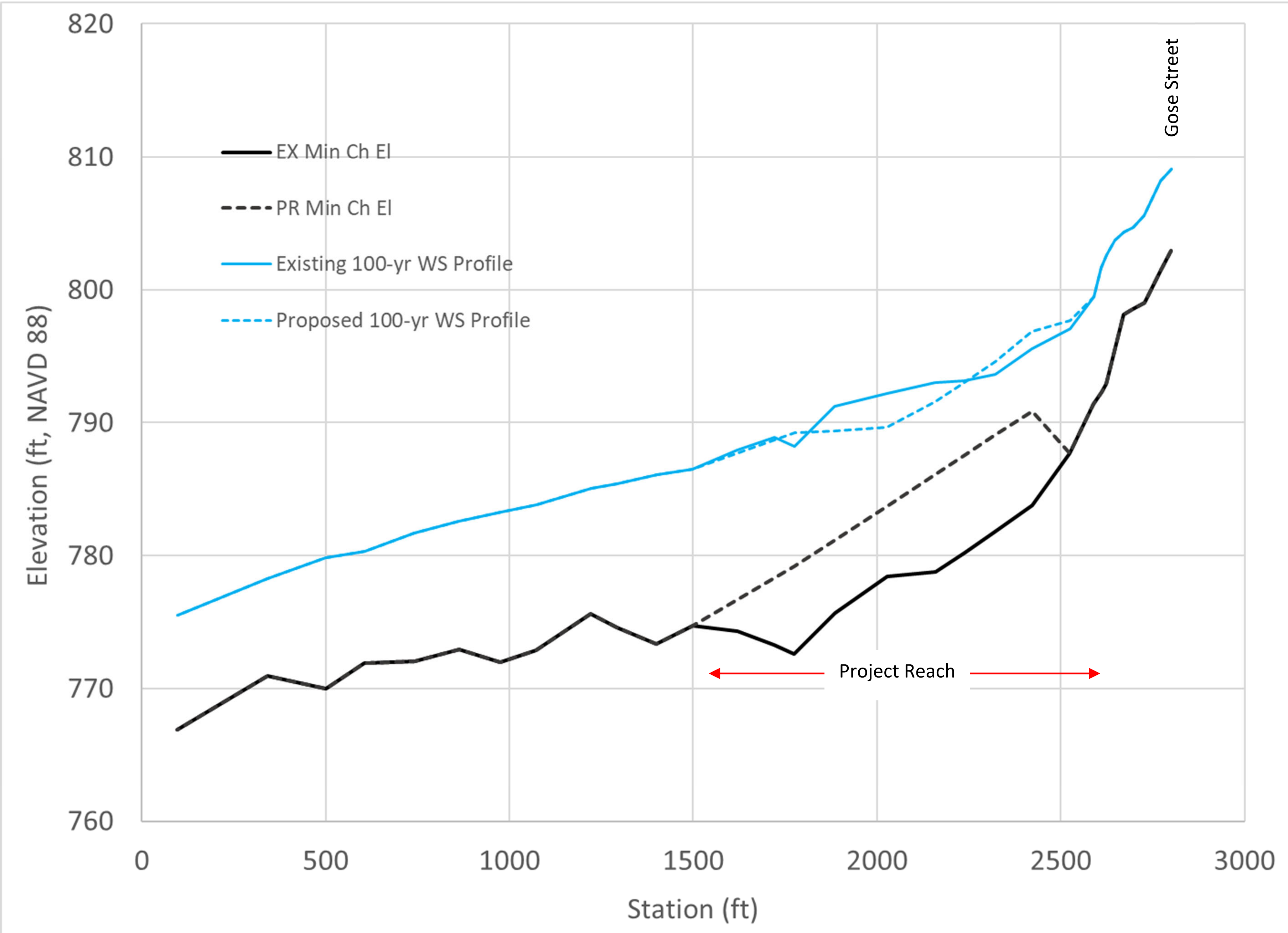
**Incipient Motion (Shields) Calculations:**

| Critical Shear Stress (psf) | Diameter of Largest Particle Mobilized (in) |
|---|---|
| 1.2 | 2.5 |
| 1.7 | 3.6 |
| 2.3 | 5.0 |
| 3.3 | 7.1 |
| 4.7 | 10.1 |

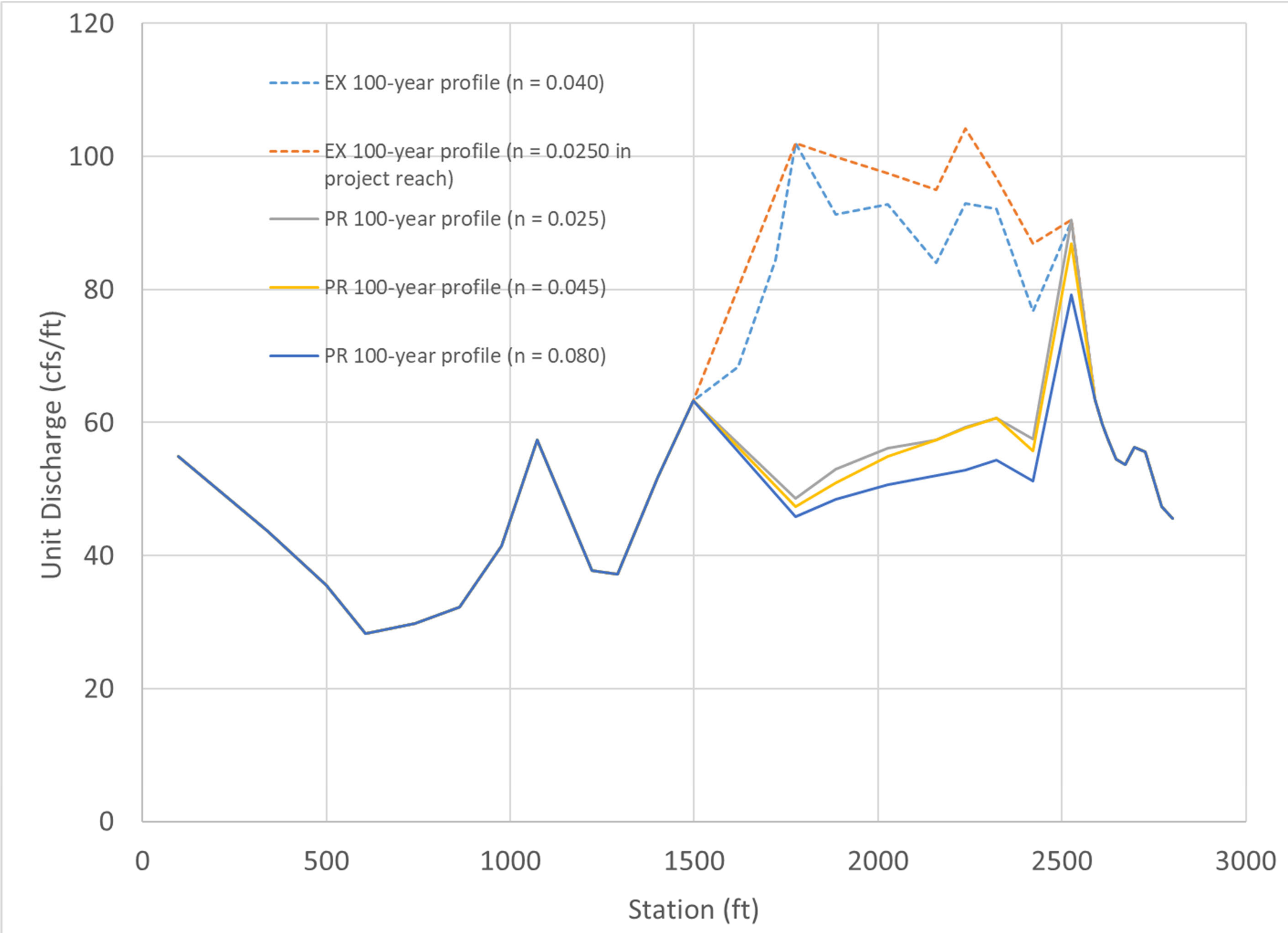


# APPENDIX B2 – OPTION 2 1D HEC RAS MODEL RESULTS


805
800
795
790
785
780
775
Elevation (ft, NAVD 88)
0
20
40
60
80
100
120
140
160
180
Station (feet)
Existing Channel
Proposed Channel
Existing 100-yr WSEL
Proposed 100-yr WSEL
50-ft bottom width
741.44
862.74
975.4
1072.42
1291.91
1399.97
1498.07
1774.82
1885.17
2026.69
2158.13
2237.6
2321.28
2421.8
2525.21
2611.09
2696.09
2800
Estimated extent of left bank grading



Gose Street
EX Min Ch El
PR Min Ch El
Existing 100-yr WS Profile
Proposed 100-yr WS Profile
Project Reach
Elevation (ft, NAVD 88)
Station (ft)
820
810
800
790
780
770
760
0
500
1000
1500
2000
2500
3000



EX 100-year profile (n = 0.040)
EX 100-year profile (n = 0.0250 in project reach)
PR 100-year profile (n = 0.025)
PR 100-year profile (n = 0.045)
PR 100-year profile (n = 0.080)
Unit Discharge (cfs/ft)
Station (ft)
0
20
40
60
80
100
120
0
500
1000
1500
2000
2500
3000

Nelson Dam Nature-Like Fishway, Naches River. Constructed 2021/22.  Slope ~ 2%

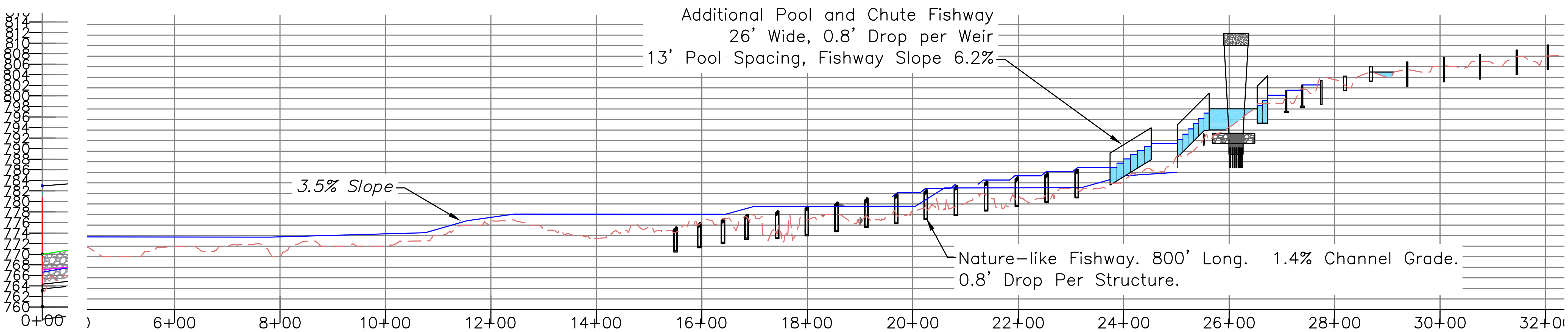
## APPENDIX C – STAKEHOLDER COMMENTS

Not Complete

## APPENDIX D – COST ESTIMATES

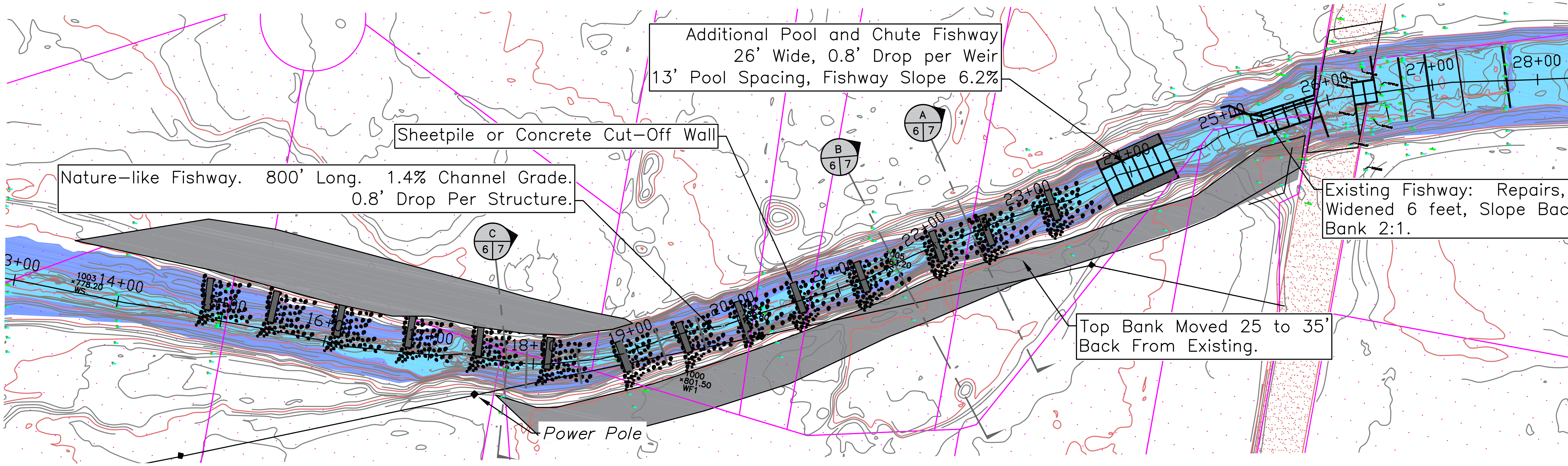
Not Complete

## APPENDIX E1 – CONCEPTUAL DESIGN DRAWINGS (5 OPTIONS)




Profile - 1 to 10 Skew

SCALE: Vertical 1" = 20', Horizontal 1" = 200'




Plan View Option 1

Scale: 1" = 100'

TRI-STATE STEELHEADERS Since 1965

Mill Creek Fish Passage

Gose Street Conceptual Design

| REV | DATE | BY | APP'D | DESCRIPTION |
|---|---|---|---|---|
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SCALE VERIFICATION

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1"

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DESIGN BY: Waterfall Engineering

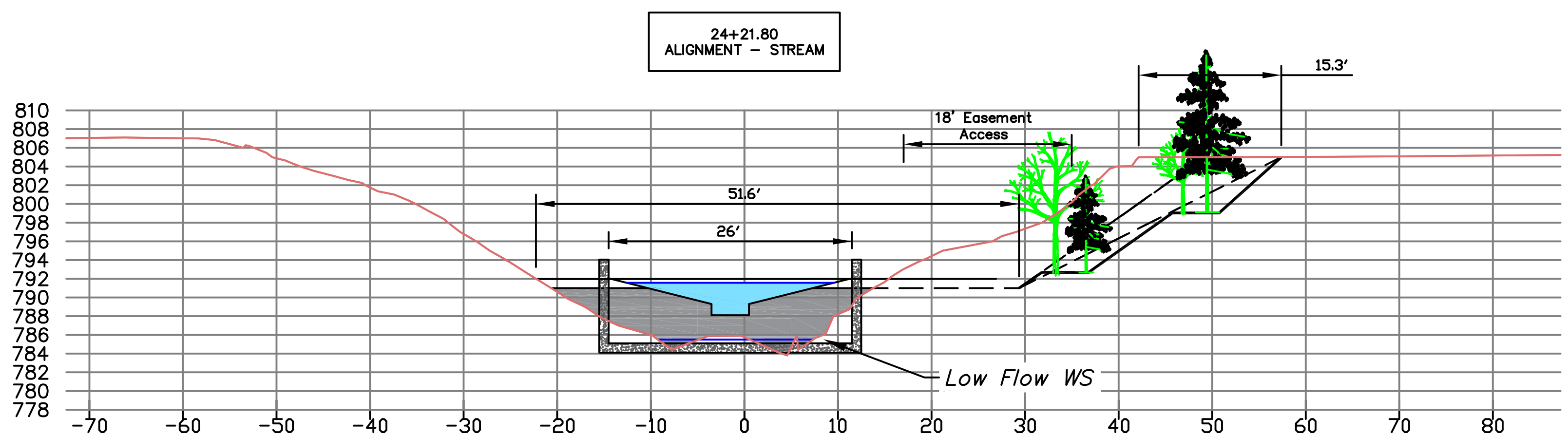
DRAWN BY:

DATE: 2/27/23

Option 1

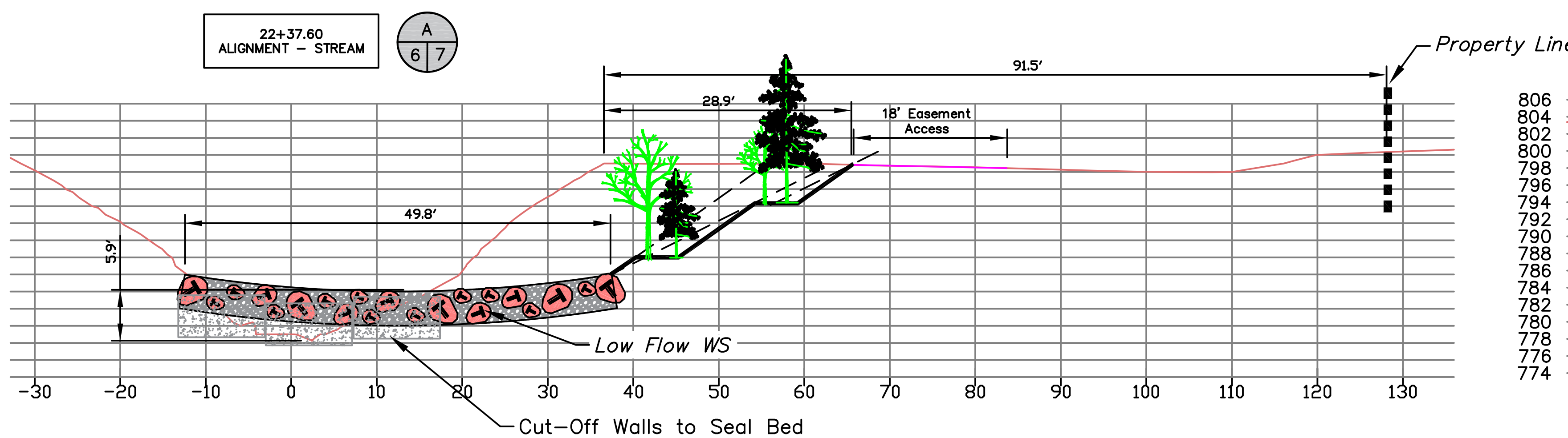
Nature Like Fishway and Pool and Chute Fishway

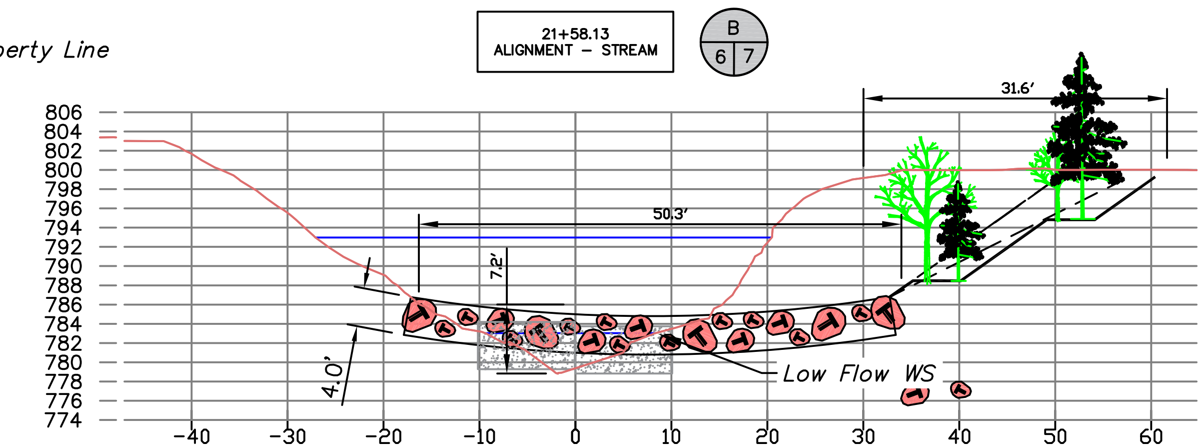
6 SHEET 18 OF

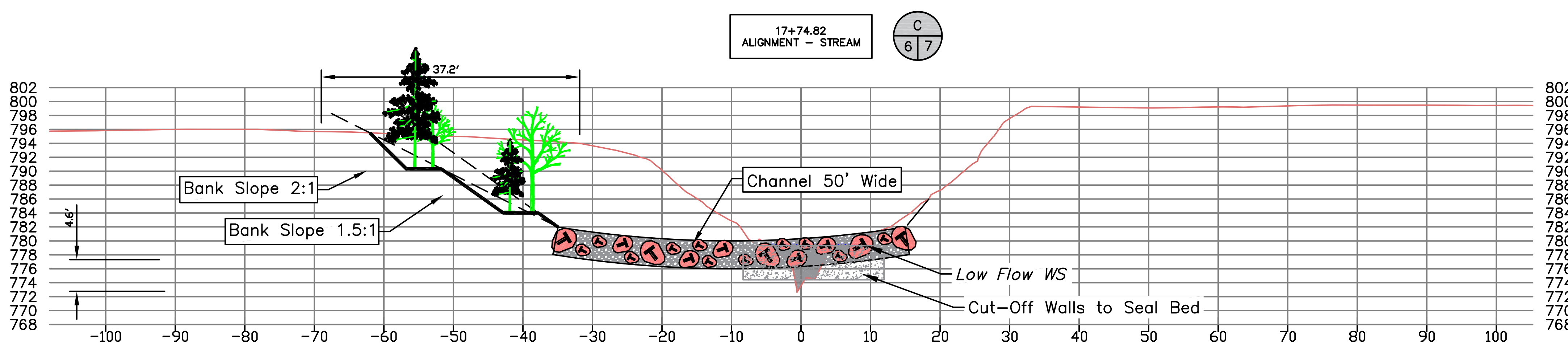



## Section at Pool and Chute Fishway

Scale: 1" = 20'




## Stream Sections - View Upstream

Scale: 1" = 20'

Mill Creek Fish Passage

Gose Street Conceptual Design

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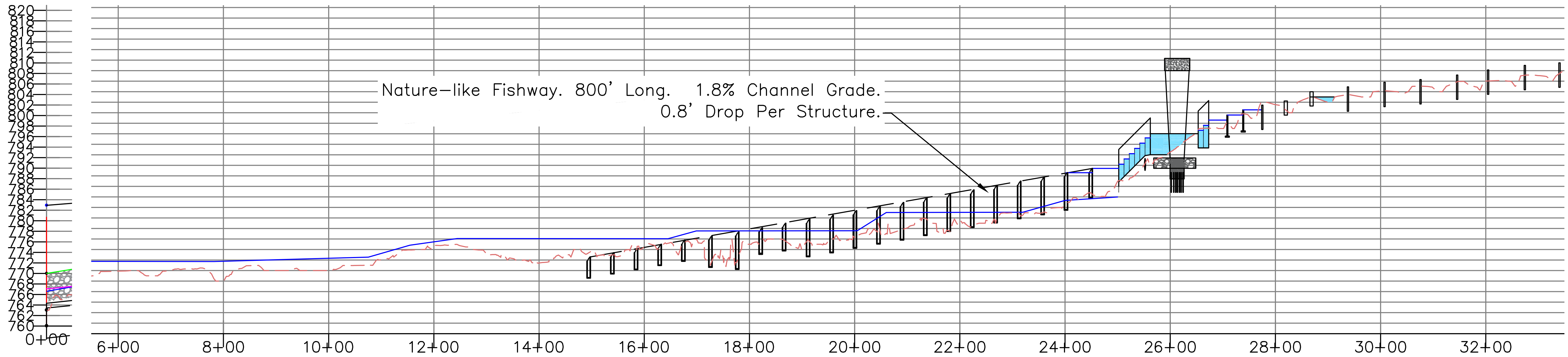
Option 1 - Sections
Nature Like Fishway and
Pool and Chute Fishway

7 SHEET 18 OF




Profile - 1 to 10 Skew

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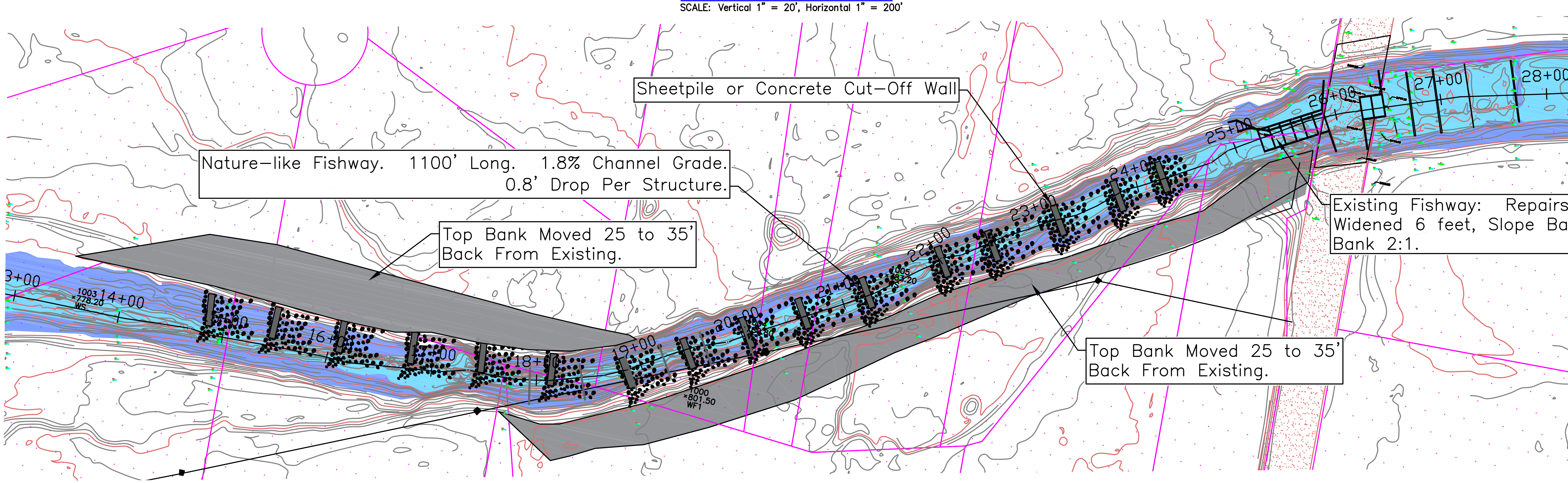


Plan View - Option 2

Scale: 1" = 100'

Mill Creek Fish Passage

Gose Street Conceptual Design

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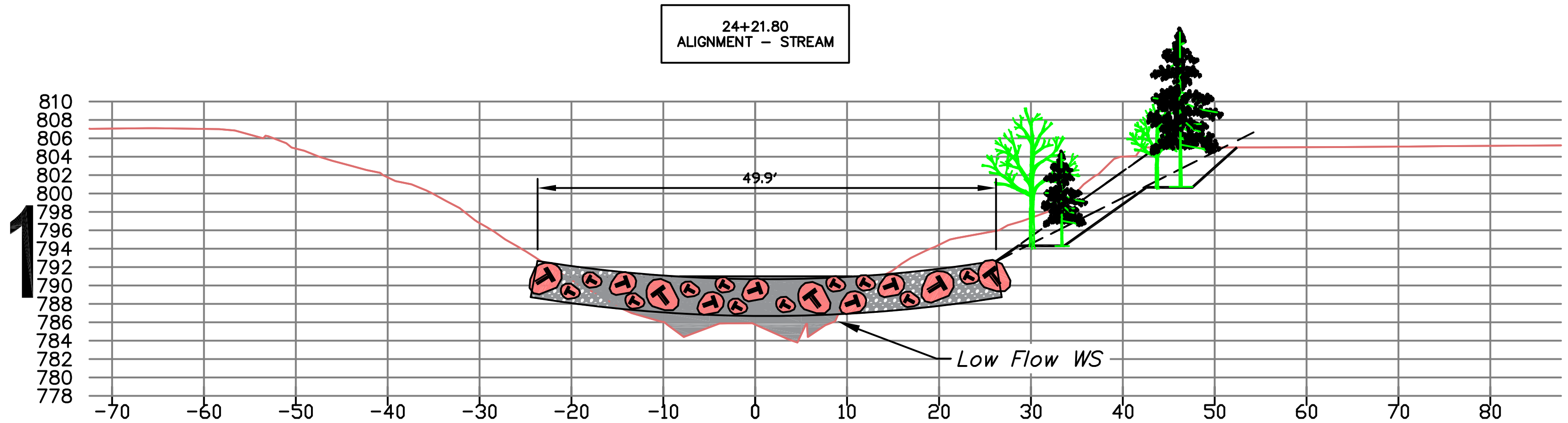
DATE:
2/17/2023

Option 2

Nature-like Fishway

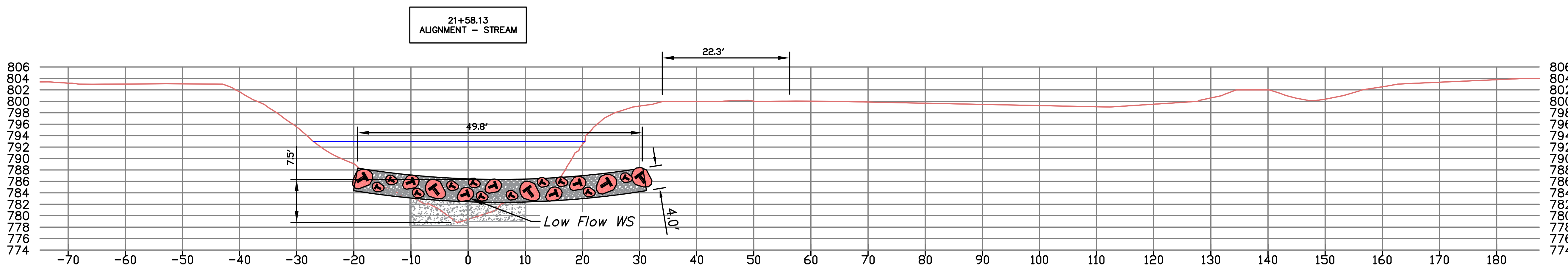
8 SHEET

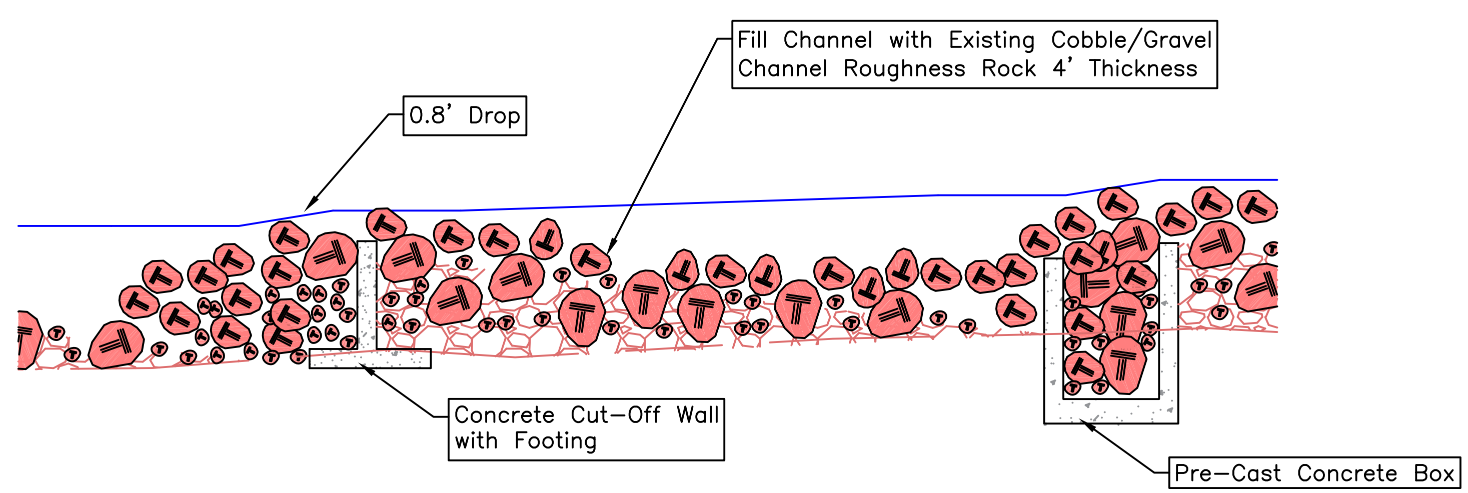
18 OF




## Section View Upstream

Scale: 1" = 20'




## Typical Boulder Sills with Concrete Control

Scale: NTS

Mill Creek Fish Passage

Gose Street Conceptual Design

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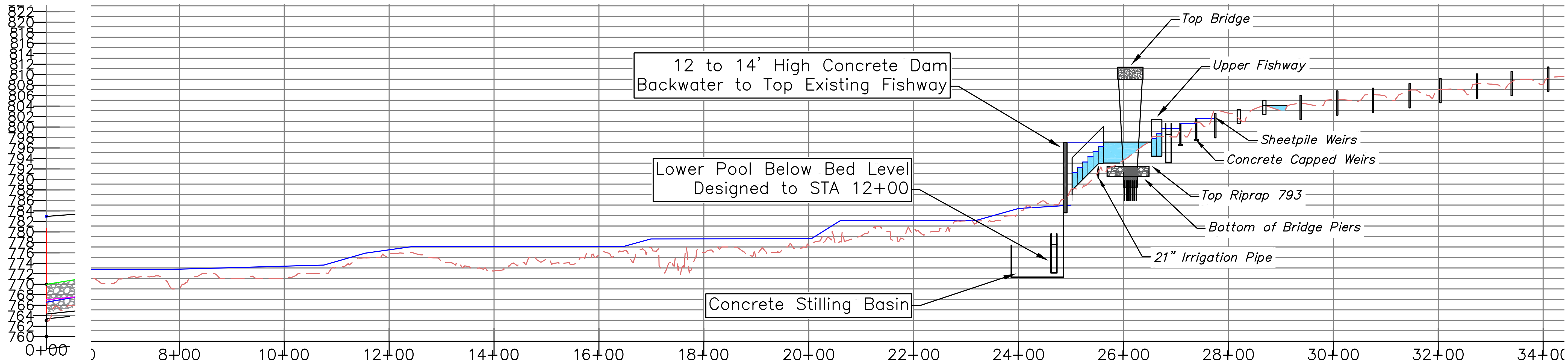
Option 2 - Sections Details

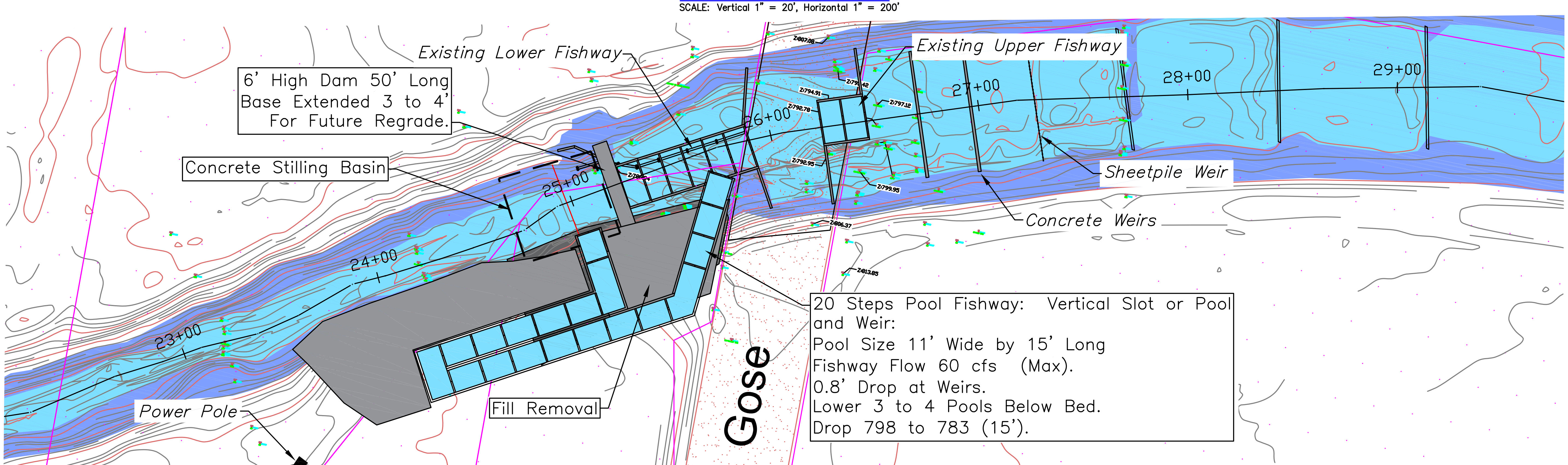
Nature-like Fishway

9 SHEET 18 OF




Profile - 1 to 10 Skew

SCALE: Vertical 1" = 20', Horizontal 1" = 200'

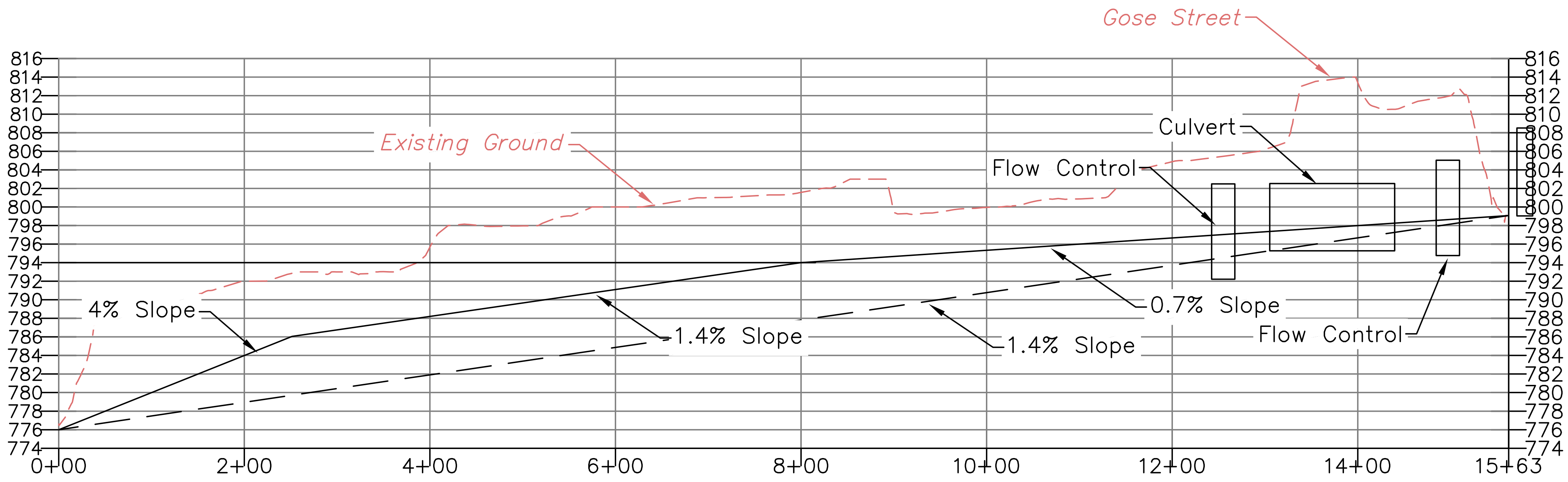



Plan View - Option 3 - Pool and Weir Fishway

Scale: 1" = 50'

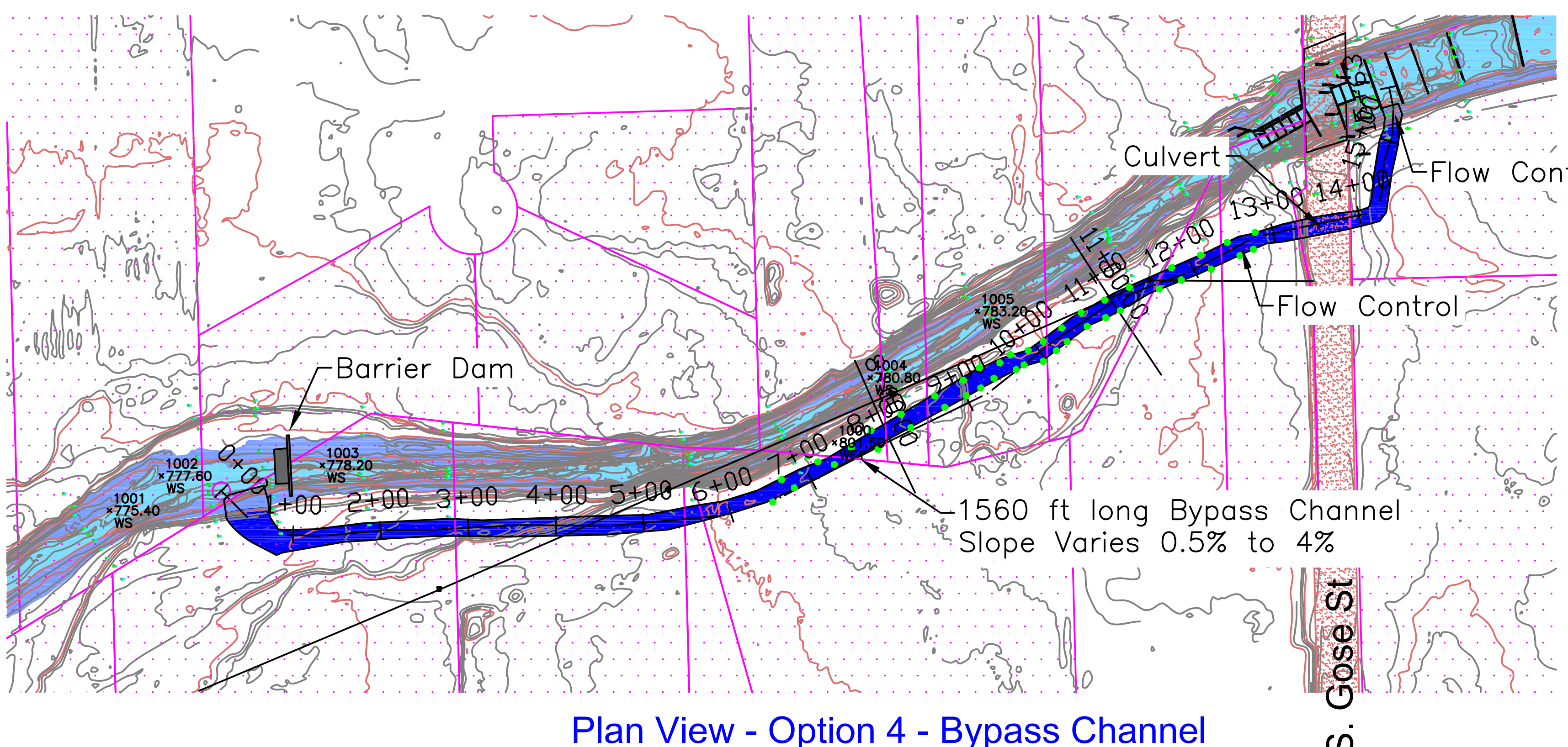
| | | | |
|---|---|---|---|
| Mill Creek Fish Passage<br>Gose Street Conceptual Design | REV / DATE / BY / APP'D / DESCRIPTION<br>SCALE VERIFICATION — BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY. | DESIGN BY: Waterfall Engineering<br>DRAWN BY:<br>DATE: 2/17/2023 | Option 3<br>Pool and Weir Fishway<br>with Dam |

9 SHEET 18 OF



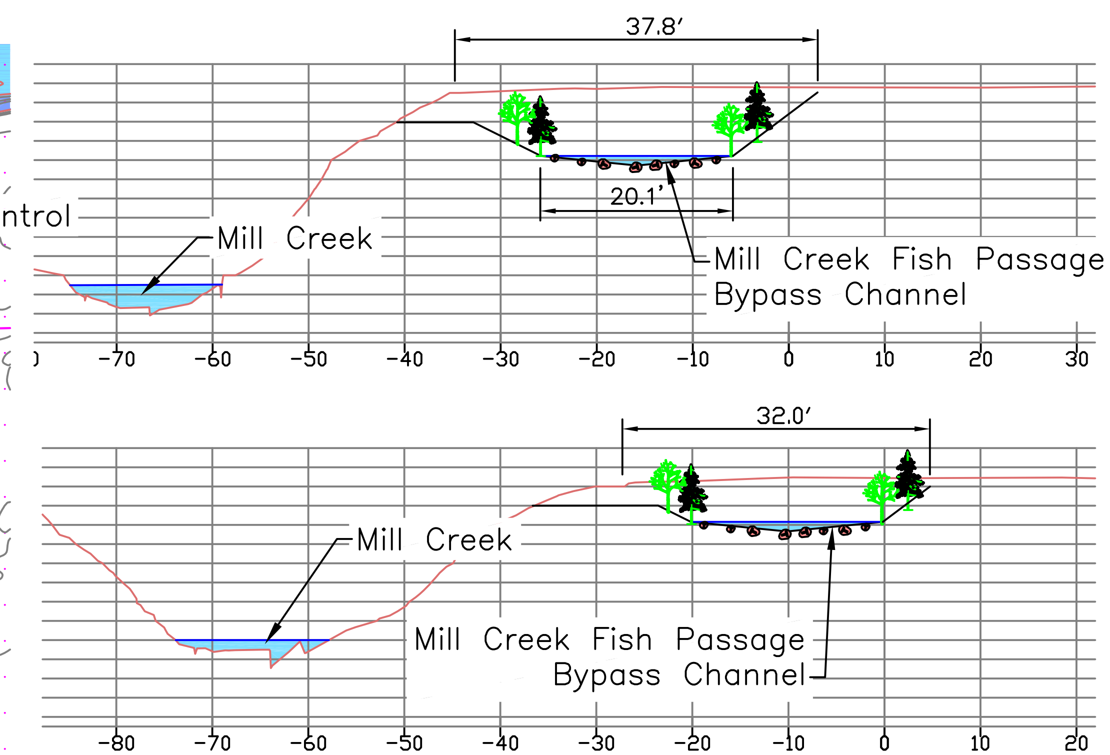

## Profile - 1 to 10 Skew

SCALE: Vertical 1" = 15', Horizontal 1" = 150'




## Plan View - Option 4 - Bypass Channel

Scale: 1" = 200'




## Typical Sections Top = 8+00, Bottom = 11+00

Scale: 1" = 20'

View Upstream

92 cfs

3500 cfs

Bypass Channel

TRI-STATE STEELHEADERS Since 1965

Mill Creek Fish Passage

Gose Street Conceptual Design

| REV | DATE | BY | APP'D | DESCRIPTION |
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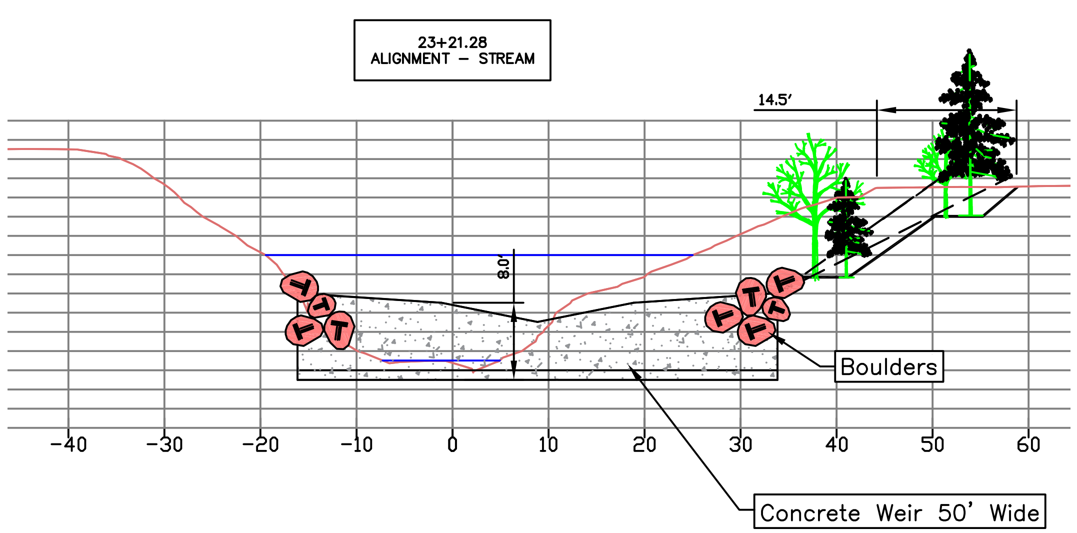
DATE: 2/17/2023

Option 4

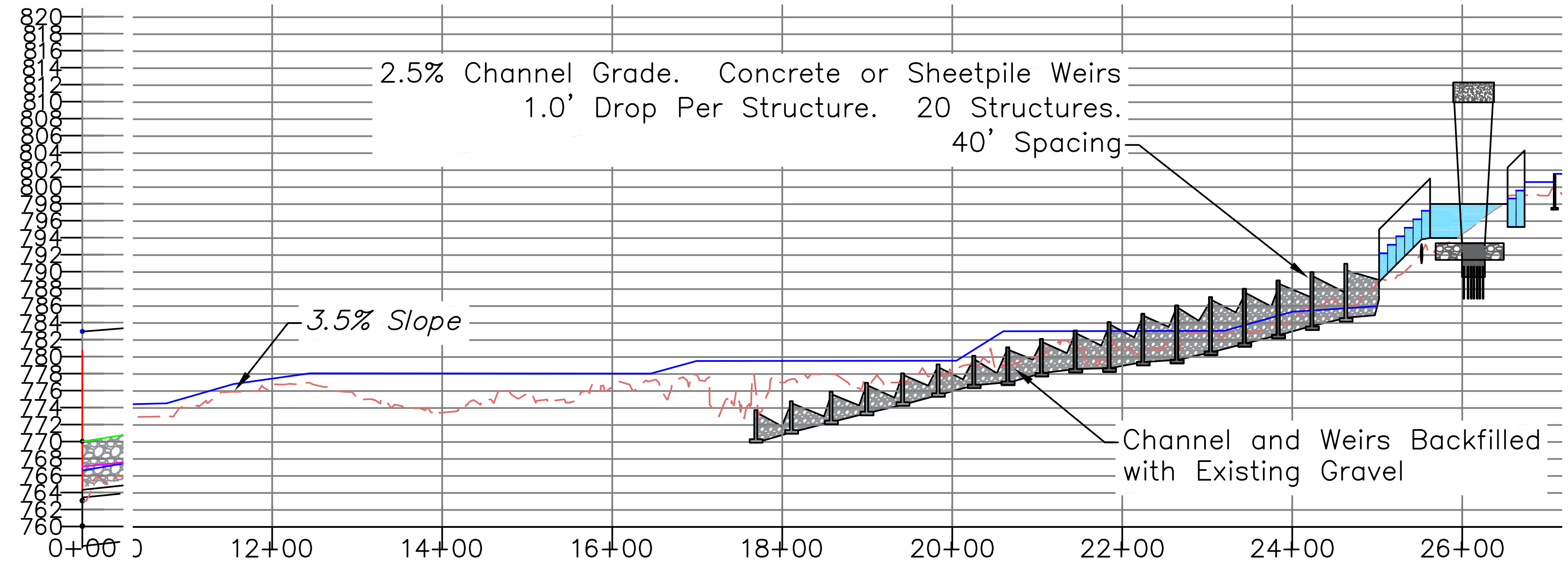
Bypass Channel

10 SHEET 18 OF



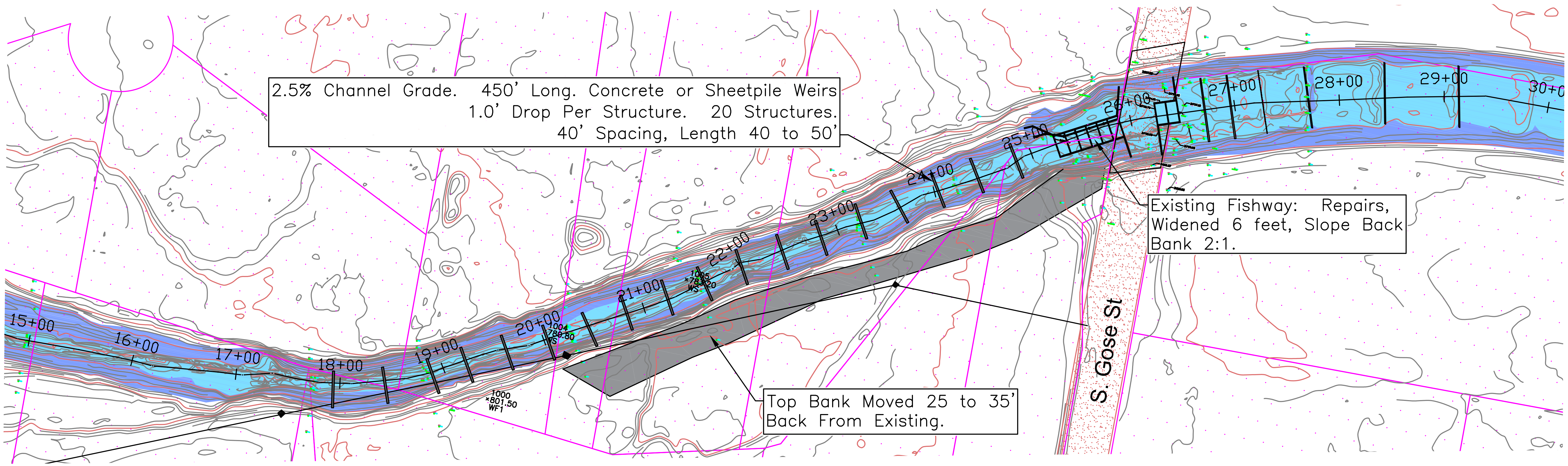

## Stream Sections - View Upstream

Scale: 1" = 20'




## Profile - 1 to 10 Skew

SCALE: Vertical 1" = 20', Horizontal 1" = 200'




## Plan View - Option 5

Scale: 1" = 100'

TRI-STATE STEELHEADERS Since 1965

Mill Creek Fish Passage

Gose Street Conceptual Design

| REV | DATE | BY | APP'D | DESCRIPTION |
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DESIGN BY: Waterfall Engineering

DRAWN BY:

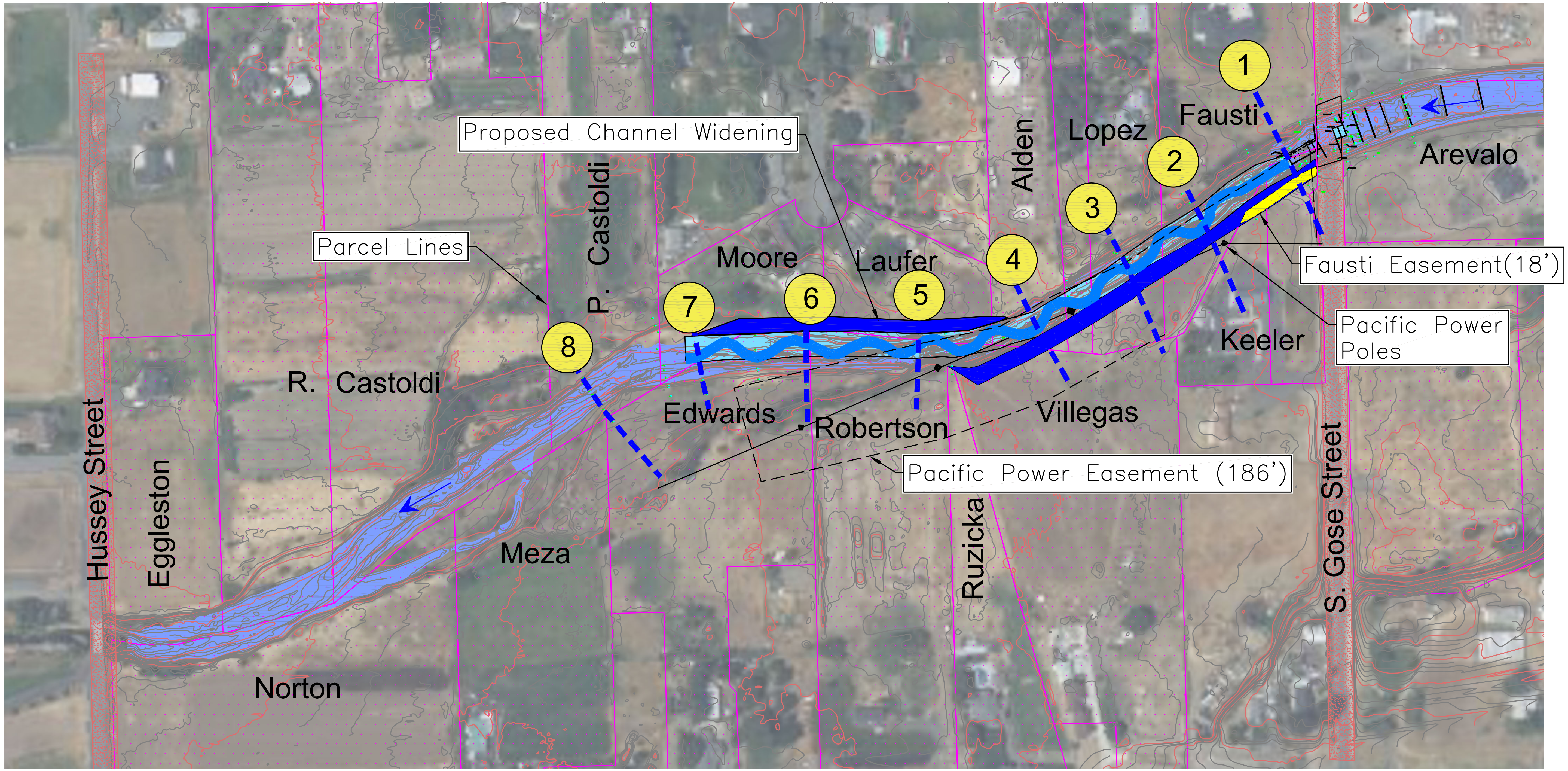
DATE: 2/27/23

Option 5

11 SHEET 18 OF

## APPENDIX E2 – OPTION 2 SELECTED DESIGN

Mill Creek 100–yr Flood
Channel Widening
Proposed 10' Meandering Thalweg
Easements
Proposed 50' Wide Channel
Cross Sections




Site Plan
SCALE: 1"= 200'
0 200

| | |
|---|---|
| Mill Creek Fish Passage<br>Gose Street Conceptual Design<br>Nature Like Fishway - Constructed Riffle/Pool | Site Plan - Option 2<br>Scale 1" = 200' |

| REV | DATE | BY | APP'D | DESCRIPTION |
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SCALE VERIFICATION
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DATE: 4/13/23

1 SHEET 6 OF

Mill Creek 100–yr Flood

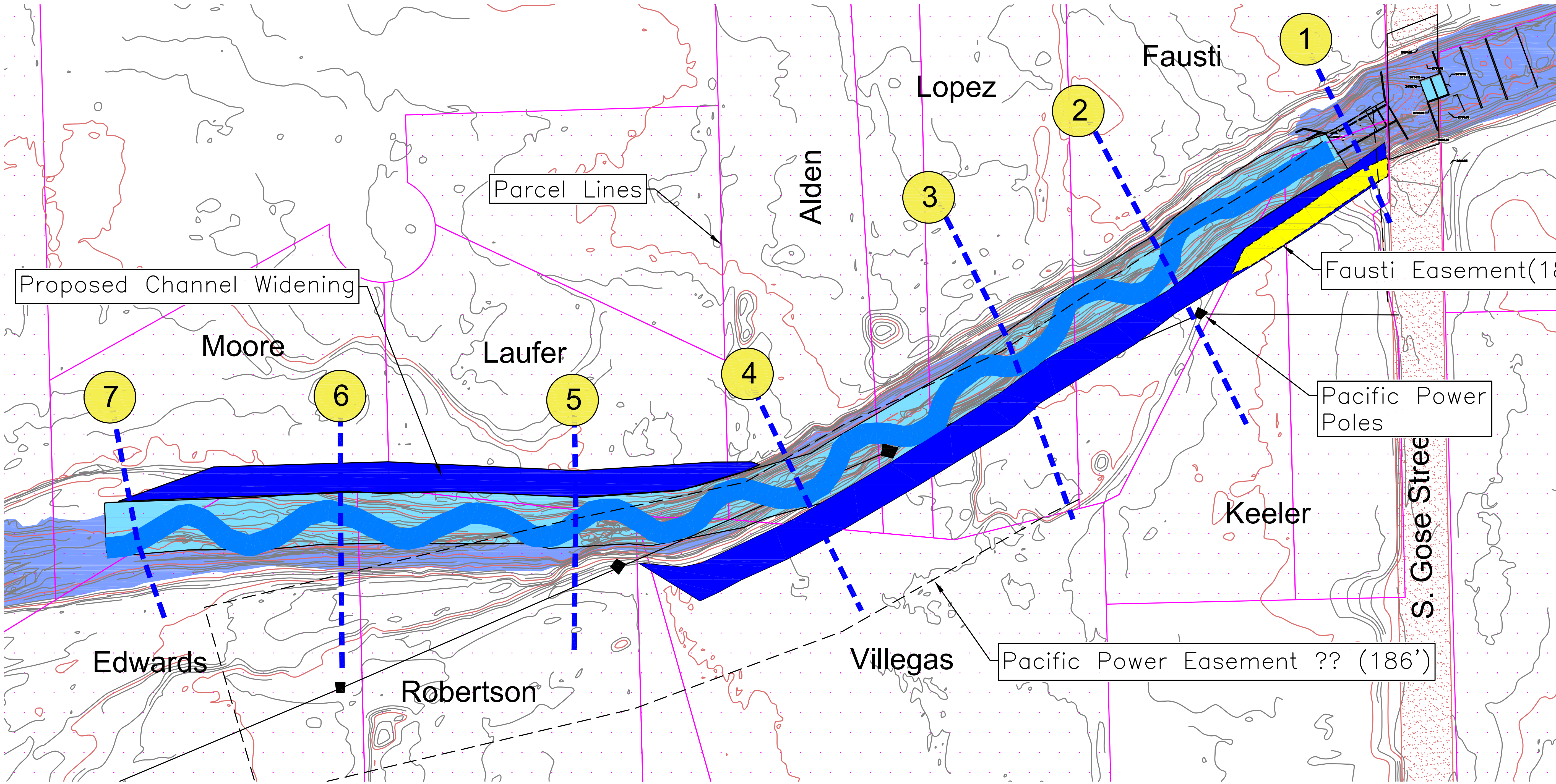
Channel Widening

Proposed 10' Meandering Thalweg

Easements

Proposed 50' Wide Channel

Cross Sections




Site Plan

Scale: 1" = 100'

0 200

Mill Creek Fish Passage
Gose Street Conceptual Design
Nature Like Fishway - Constructed Riffle/Pool

| REV | DATE | BY | APP'D | DESCRIPTION |
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DESIGN BY: Waterfall Engineering

DRAWN BY:

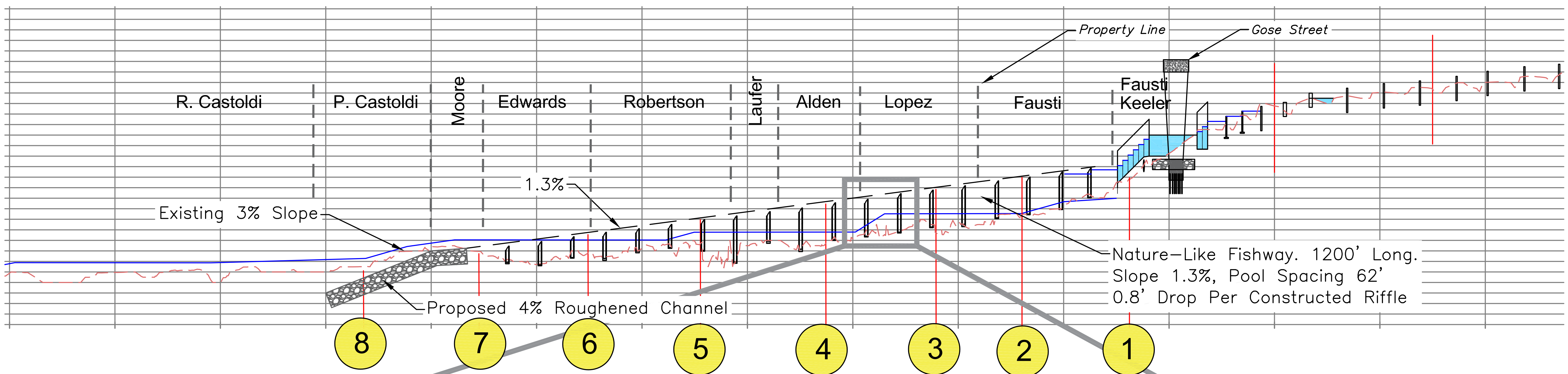
DATE: 3/29/23

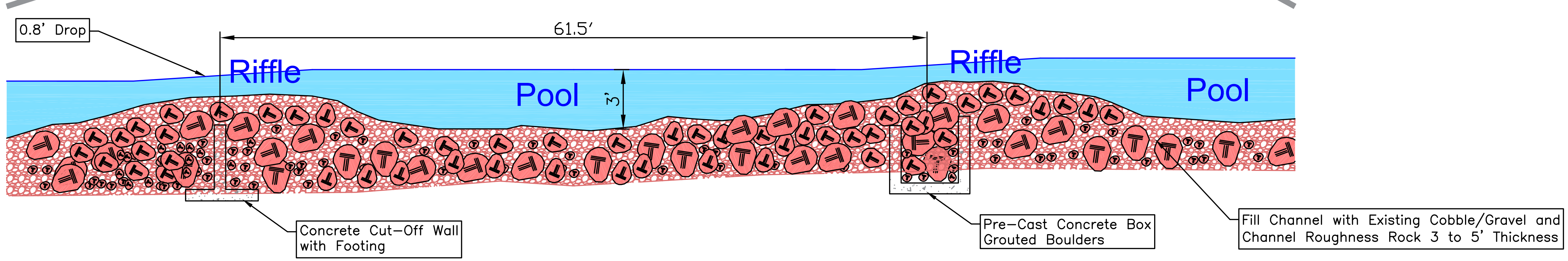
Site Plan - Option 2
Scale 1" = 100'

2 SHEET 6 OF

## Profile - 1 to 10 Skew

SCALE: Vertical 1" = 20', Horizontal 1" = 200'




## Typical Boulder Sills with Concrete Control

Scale: 1" = 10'

Mill Creek Fish Passage

Gose Street Conceptual Design

| REV | DATE | BY | APP'D | DESCRIPTION |
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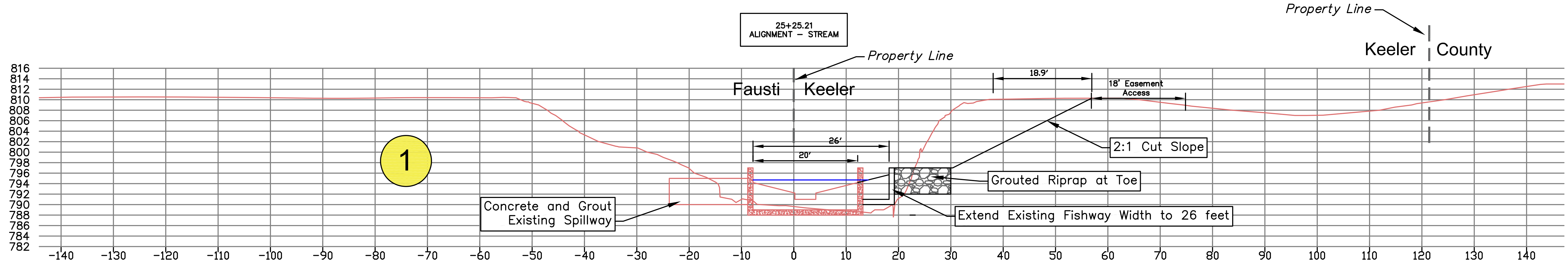
DATE: 4/14/23

Option 2

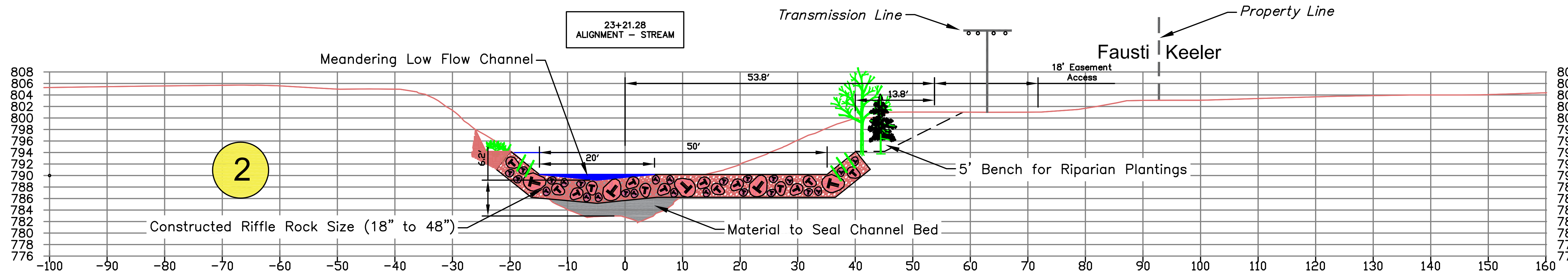
Nature-Like Fishway Profile

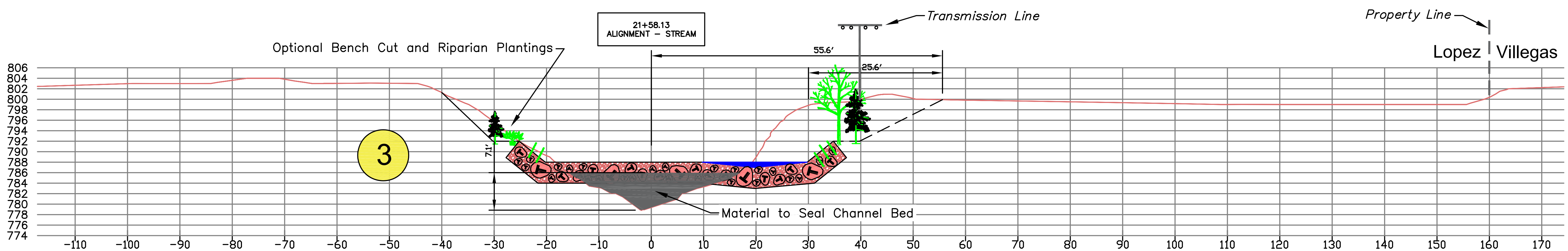
3 SHEET 6 OF




## Section View Upstream

Scale: 1" = 20'




Mill Creek Fish Passage

Gose Street Conceptual Design

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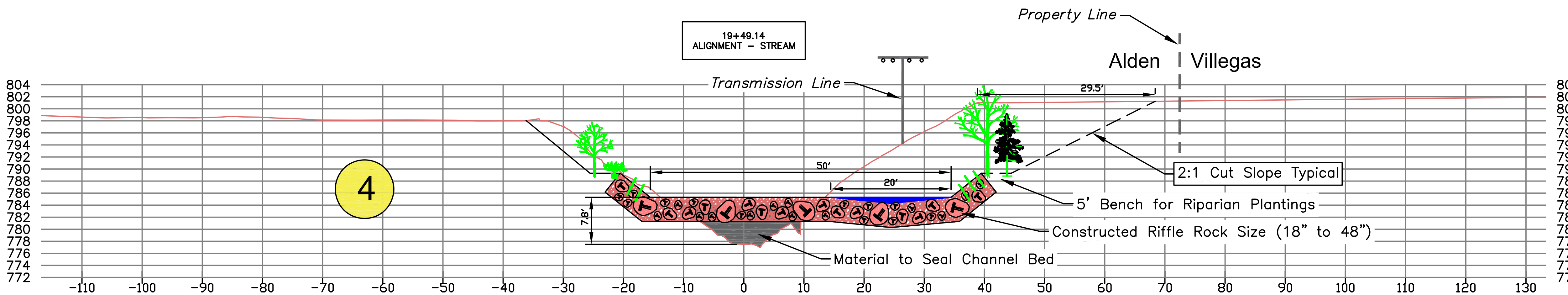
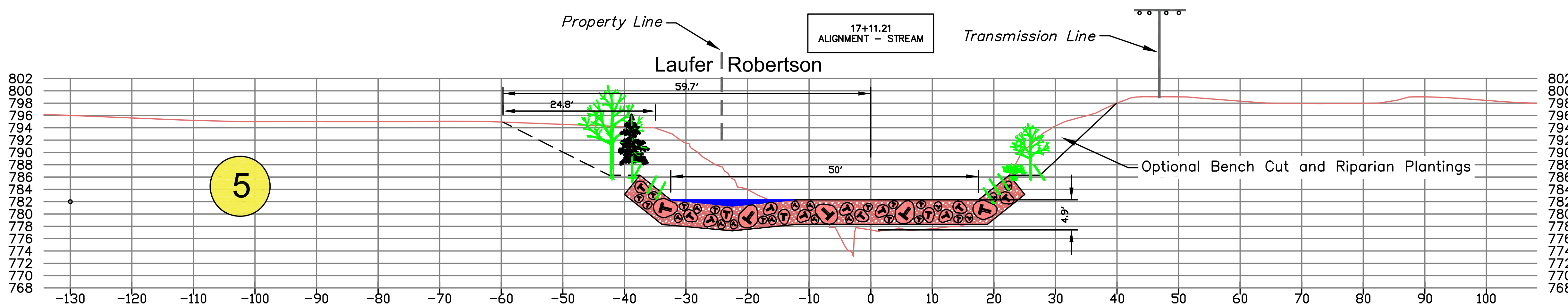
Option 2 - Sections
1 to 20 Scale
Nature-like Fishway
Constructed Riffle/Pool

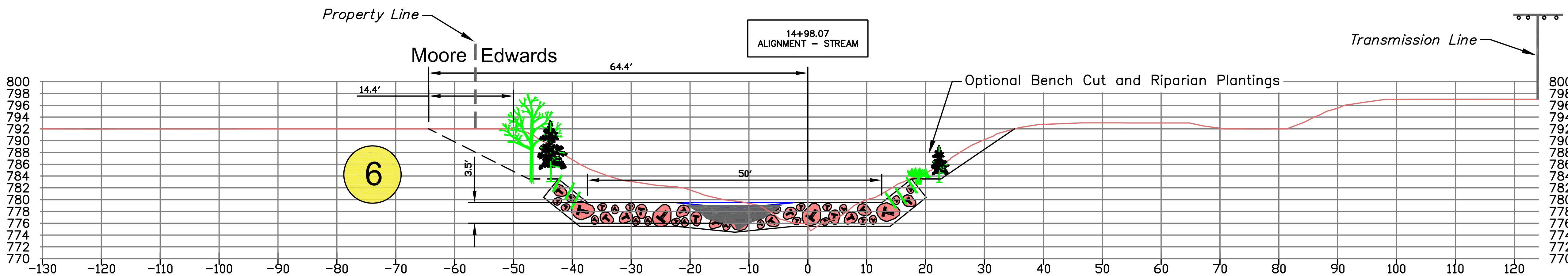
4 SHEET 6 OF




Section View Upstream

Scale: 1" = 20'




Mill Creek Fish Passage

Gose Street Conceptual Design

| REV | DATE | BY | APP'D | DESCRIPTION |
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SCALE VERIFICATION

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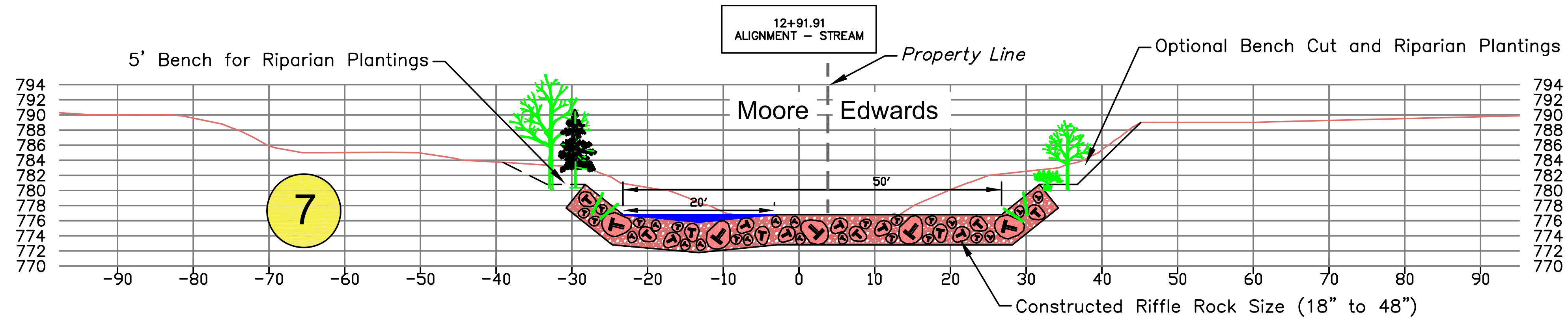
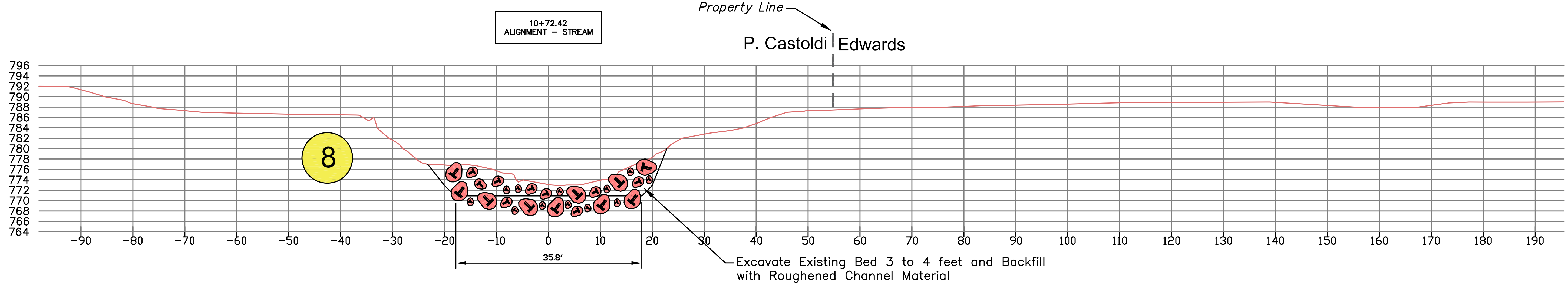
Option 2 - Sections
1 to 20 Scale
Nature-like Fishway

5 SHEET 6 OF




## Section View Upstream

Scale: 1" = 20'




## Section View Upstream

Scale: 1" = 20'

TRI-STATE STEELHEADERS Since 1965

Mill Creek Fish Passage

Gose Street Conceptual Design

| REV | DATE | BY | APP'D | DESCRIPTION |
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SCALE VERIFICATION

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DATE: 4/14/23

Option 2 - Sections
1 to 20 Scale
Nature-like Fishway

6 SHEET 6 OF

## APPENDIX F – ALTERNATIVES ANALYSIS SCORING MATRIX

# Mill Creek/Gose Street – Fish Passage Design Options and Project Attributes Listed in Ranked Order

***Project Goal: Develop a Conceptual Plan for fish passage which addresses flood protection, secure infrastructure, long-term and low maintenance.***

| | | **Project Attributes** – *Each Given a Weighted Ranking of 1 to 5, 5 meaning very important to the overall project goal and 1 least important to project objective* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Rating Note: Each Design Option is rated from 1 to 10, 10 = fully addresses the attribute and, 1 = does not address the attribute.* | **Final Ranking Max = 310** | [1]Low Flow Fish Passage (3) | [2]High Flow Fish Passage (5) | [3]Risk to Infrastructure (2) | [4]Channel Incision (4) | [5]Maintenance (4) | [6]Landowner Concerns (3) | [7]Maintain Flood Control (3) | [8]Constructability (3) | [9]Cost (3) |
| **Option 0: Do Nothing** | **106** | 0 | 1 | 5 | 1 | 5 | 2 | 8 | 5 | 10 |
| **Option 1: Nature-like Fishway (800' Long) with Pool and Chute Fishway** - Backwater existing fishway with a new Pool and Chute Fishway and a 800 foot long, 1.4% slope Nature-like Fishway. Drops may have concrete or sheet pile cutoff walls to seal channel bed. Channel would be widened to 50 feet and banks sloped back. | **234** | 7 | 8 | 8 | 9 | 7 | 7 | 8 | 8 | 8 |
| **Option 2: Nature-like Fishway (1000' Long)** – Backwater existing fishway with a 1000-foot-long, 1.8% slope Nature-like Fishway. Drops may have concrete or sheet pile interior walls to seal channel bed. Channel would be widened to 50 feet and banks sloped back. | **231** | 6 | 9 | 7 | 9 | 7 | 8 | 7 | 8 | 7 |
| **Option 3: Pool and Weir Fishway with Dam:** – Construct a 20-step pool and weir fishway with a new dam across the channel. The fishway would be extended three to four feet below the bed. | **169** | 7 | 6 | 5 | 6 | 6 | 6 | 6 | 5 | 4 |
| **Option 4: Bypass Channel:** Excavate a 1560 foot long channel, 20 to 30 feet wide at slopes from 4 to 0.5%. The upstream end would require flood control measures, gates, slots, a culvert under Gose, an overflow side channel to protect landowners from flooding, a fish barrier dam downstream. | **177** | 8 | 9 | 4 | 3 | 4 | 3 | 8 | 6 | 7 |
| **Option 5: Channel Weirs:** This option would have 14 concrete or sheet pile weirs with one-foot drops to raise the existing channel up to the existing fishway. Some channel widening would be required, but not as much as Options 1 and 2. | **177** | 8 | 7 | 4 | 7 | 4 | 4 | 8 | 6 | 4 |

Scoring Notes:

1) Upstream Fish Passage: 10 = Unobstructed free passage at all flows, 1 = Poor Passage, Blocked at Some Flows, Excessive Turbulence
2) Downstream Fish Passage: 10 = Safe Passage, 1 = Potential Stranding or Injury
3) Risk to Infrastructure: 10 = Low Risk, 1 = High Risk
4) Channel Incision: 10 = Adjusts to Future Bed Levels, 1 = Future Bed Levels May Create Barrier
5) Maintenance: 10 = No site maintenance, 1 = High Site Maintenance
6) Landowner Concerns: 10 = No Concerns, 1 = Many Concerns
7) Maintain Flood Control: 10 = Maintains Existing No Risk, 1 = Reduced Flood Control High Risk
8) Constructability: 10 = No Impact on Landowners and Low Risk, 1 = Major Impact on Landowners and High Risk
9) Cost: 10 = low cost, 1 = high cost